NATURE

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Telephone Number: Regent 3891

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GOVERNMENT SCIENTIFIC RESEARCH IN GREAT BRITAIN

DURING the past year there has been evident in Parliament, from time to time, a desire for fuller information regarding the work of the Department of Scientific and Industrial Research. While strong support was forthcoming in a debate in the House of Commons last June for the Advisory Council's plea, in its last year's report, for more continuity in the financial support of the Department's work, members of Parliament are manifestly and rightly concerned to satisfy themselves that the considerable sums concerned, approaching £6 millions in the estimates for 1953–54, are expended wisely and without waste. There has been little criticism of the general basis of the Department's plans to meet post-war needs, though some concern has been expressed at the delay in giving full effect to those plans; and, according to the Department's report for 1950–51, this was even then causing grave anxiety to the Advisory Council.

The report of the Department for the year 1951–52, which has now been published (see p. 716 of this issue), while making a praiseworthy effort to provide the detailed information which Parliament is seeking, is marked by the same note. "Nothing," writes the Advisory Council, "has since occurred to mitigate our anxiety. In fact, we find ourselves reviewing the relation between our scientific needs and our scientific resources with steadily deepening concern." The difficulty of drawing a balance between advisory and *ad hoc* work on one hand, and longer range research on the other, is recognized; but while agreeing with those who, like Sir Henry Tizard, stress the utmost importance of widely disseminating and using to the full existing information, the Advisory Council points to evidence that deficiencies in knowledge have often to be made good before fully satisfactory answers can be found to some of the problems and inquiries put to the Department. These deficiencies will become more serious as industry becomes more conscious of the help to be gained from science, unless the reservoir of scientific knowledge from which answers are derived is enlarged by further research.

"We and our colleagues on the Advisory Boards," continues the Advisory Council, "are already deeply concerned at the inadequacy of the effort the D.S.I.R. Establishments can devote to the longer range research. Basic research is hardly worth doing if the effort that can be devoted to it is insufficient to secure steady progress, and the suggestions made from time to time to reduce the present meagre effort appear to us to be ill-founded. We remain firmly of the view that there is no alternative to the planned expansion of the D.S.I.R. that our predecessors recommended six years ago."

In spite of this comment, however, the Advisory Council gives little or no information as to the present position of what are described in its previous report as the most urgent items in the Department's building programme. After a delay of twelve months due to the standstill on civil building work, work was begun on the second new laboratory building for mechanical

engineering research in May 1952, but construction of the Heat Transfer and Creep Laboratories has still not begun. While the expenditure in this field increased from £137,566 in 1950–51 to £267,434 in 1951–52, much work has still to be carried out at the National Physical Laboratory, or at the universities under contract—and this when the industries which the new laboratory will serve are responsible in the aggregate for exports to the value of £750 millions a year and play the most important part in rearmament.

While such slender progress is being made in discharging the Department's obligation to develop the new Mechanical Engineering Research Laboratory as the chief national centre for basic research in all branches of mechanical engineering, progress in the development of the Hydraulics Research Station at Wallingford has been equally slow. The damage done to the coastal defences of Britain by the high tides and gales early this year points to the danger of neglect in this field and the probable cost to the nation of delay. The work of Lord Waverley's committee would probably be greatly assisted had this Station already been fully in operation. Apart from this, as noted in last year's report, important contracts have been lost to Britain through the absence of a centre with facilities for basic research and experiments with models on coast erosion and accretion, the effect of dredging and drainage schemes on estuaries and rivers, and the design of dock and harbour works so as to avoid silting. Experimental work in Britain is still in its preliminary stages, and relies on the National Physical Laboratory and the Imperial College of Science and Technology. Nor does the report indicate whether or not there has been further delay in letting the contract for the erection of the new Water Pollution Research Station at Stevenage or acquiring a site for a new Road Research Laboratory. Design work on the project for the new tank and water-tunnel which was stopped in October 1951 has, however, been resumed; but it appears that, since the project is still "subject to review in the light of the current economic situation", the importance of an up-to-date 'tank' and ancillary equipment for studying the design of ships' hulls is not fully appreciated, although Britain still constructs one-third of the world's shipping.

Some attention is given in the present report to the remaining two matters in the building programme which were stressed last year as specially urgent—the Radio Research Station and the Building Research Station. The hope is expressed that the construction of the permanent buildings on the site at Slough, referred to in the previous report, will be commenced in 1953, but meanwhile the work has to continue partly in huts and partly at the National Physical Laboratory. Apart from a small amount of fundamental research in progress at two universities, with support from the Department of Scientific and Industrial Research, the Radio Research Station is the only establishment in Great Britain doing fundamental work in this field.

The Radio Research Station was one of the three establishments specially visited by the Advisory Council during the past year, and it was noted that at present about half the staff of the organization is engaged in work on propagation and about one-third on research on properties of materials used in radio construction. The Council was impressed by the unanimous opinion which it encountered that, while increased facilities are urgently needed, so that more effort can be directed to problems of importance to the manufacturing side of the industry, this effort should not be obtained by curtailing research on propagation. It was also regarded as essential, in the present stage of the development of radio forecasting, that those engaged in it and in organizing ionospheric observations should continue to work in close conjunction with those carrying out research on propagation. Nevertheless, the Summary of Expenditure appended to the report shows that expenditure on radio research was reduced by some 20 per cent during 1951–52.

We refer later to two features of the Department's work which are well illustrated by the position of the Radio Research Station, and pass to the work of the Building Research Station. The Advisory Council was also impressed by the work of this Station and its practical value to the building and contracting industries. It stresses particularly the investigation of the causes of defects in buildings; the work on thermal and acoustical insulation of buildings and on heating systems; and the work on alternative methods of construction, which has saved the industry much wasted effort. The Station has evolved a cheaper and better mortar, now in general use, and has shown how substantial economy in cement can be achieved in concrete and in external rendering. Current work on the causes of heavy maintenance costs of buildings and on eliminating unnecessary handling of materials during construction is also noted, and an experimental study of the planning of dwellings conducted in co-operation with housewives has led to modifications in the planning and equipping of kitchens which should result in economy in cost and increased satisfaction to the housewife.

It appears that the industry is taking more notice of the results of this work, which are being applied more widely. The Advisory Council is satisfied that, to meet the increasing needs of the industry and to economize in man-power, it is essential that the various branches of the work of the Station should be brought together on a single site with as little delay as possible. The report gives, however, no indication as to the progress made in the reconstruction and extension of the Building Research Station, of which the previous report had stated: "far more remains to be done, including the acquisition of additional land".

In view of this, it is surprising to find in the report of the Committee of the Privy Council that the resources available for building research are to be curtailed. There may be some substance in the view that the staff employed in building research in October 1951 represented an excessive proportion of the restricted total staff available for the Department, and the Committee of the Privy Council points out that when the reduction has been made the non-industrial staff for building research is more than one-seventh of the total for all the Department's

research establishments and more than one-and-a-half times as large as that of any other establishment except the National Physical Laboratory. In the estimates for 1953–54, the actual reduction in staff is given as 39 on the 1952–53 figure of 577, and the expenditure as £366,790, compared with £378,904 for 1952–53. Even more surprising is the contrast between this decision and the firmness with which the Government holds to its programme of building three hundred thousand houses a year.

Even if the belief that at the present time this housing programme represents too large a proportion of the country's economic resources is unfounded, it is scarcely consistent with the Government's programme of eliminating waste to hold up investigations into how to build houses more efficiently and cheaply. Doubts as to the wisdom of the economies which the Committee of the Privy Council or the Advisory Council proposes are further suggested by the reference in the latter's report to the Geological Survey. The Survey furnishes reliable advice to industry and to government departments on such matters as mineral deposits, water supplies and the planning of mining operations, and in connexion with the execution of many civil engineering projects. Such advice is usually based on the geological map, on which the geologist records the results of his work; present-day demands for geological information require the compilation of such maps on a scale of six inches to the mile for most areas of Great Britain. When the Department of Scientific and Industrial Research prepared its post-war plans, it was estimated that some 33,000 square miles of Great Britain had not been surveyed on this scale, and the plan of expansion for the Geological Survey then approved provided for the completion of the mapping programme in about thirty years. At the present rate of progress it will take more than one hundred years to complete, and the Advisory Council's plea for additional staff for field-work, and its reference to the delay in dealing with inquiries caused by this slow progress, should be viewed also against the disparity between the expenditure on the Geological Survey and that, for example, on the corresponding surveys of the U.S.S.R. or the U.S.A. Nor would the increase in the estimated expenditure on the Survey to £176,706 in the 1953–54 Estimates, compared with £164,817, appear likely either to increase appreciably the rate of progress or diminish that disparity; expenditure in the United States before the Second World War was already £1 million compared with £70,000 in Great Britain.

Apart from expenditure on building research and on the National Physical Laboratory (reduced from £721,855 in 1952–53 to £666,785 in 1953–54), the 1953–54 estimates for the Department of Scientific and Industrial Research show slight increases over the estimates for 1952–53; only for radio research is there a significant increase—from £14,903 to £74,649, with an increase of 87 in the staff, to a total of 112. The impression derived from the estimates in the light of this report is of trifling and indecision, and a failure to grapple with the real issues. The resources of the Department appear to be spread too thinly over too wide a range of activities, and the Advisory Council appears to be reluctant to take the ruthless action which would really bring home to the nation and to the government the price which may be paid for niggardliness where research is concerned.

But it is not merely that proposals, such as the Committee of the Privy Council makes, for cancelling authorized vacancies in staff, are as likely to cause waste as economy: there is to be sensed something of a rift in outlook between the Committee of the Privy Council and the Advisory Council. It is hard to reconcile the former's decision, though reluctant, "that some contribution must be made by the Department in the general economies that are being made in the government service as a whole", with the "steadily deepening concern" of the Advisory Council. Nor does the effect of this decision "not to eliminate any major plan or activity, but to slow down some work and to arrest, for the time being, most of the planned expansions of activities" easily harmonize with the Advisory Council's firm view that "there is no alternative to the planned expansion of the Department of Scientific and Industrial Research that our predecessors recommended six years ago". Elsewhere, in concluding its report, the Advisory Council adds: "We are, however, becoming more and more convinced that science will never be adequately used in this country until many more scientists and technologists are employed throughout industry, not omitting the direction and management". Ostensibly the words are directed at industry and call for wider provision for higher technological education; but the Advisory Council could equally be aiming them higher.

That passage, however, concludes a discussion on technical information services and the measures being taken by the Advisory Council to stimulate the utilization of existing knowledge by industry. Reference is made here to the survey of technological resources and the requirements of industrial firms in the north-west of Britain now being conducted by the Manchester Joint Research Council; but the summary of expenditure this year does not disclose the expenditure on intelligence. With the Committee of the Privy Council's decision to seek its main economies, after building research, in the headquarters office, the omission may or may not be significant. The estimates for 1953–54 show a reduction of £14,292 in headquarters expenditure; but whether or not that has curtailed the activities of the intelligence division, the possibility of some degree of overlapping may merit examination; thus there is no clear justification in the report for the grant of £15,000 during the past three years to the Association of Special Libraries and Information Bureaux.

To suggest that major and minor activities of the Department should be rigorously scrutinized and ruthlessly pruned where their continuance on the existing scale cannot be justified in the national interest is not to advocate the reductions in the present effort which the Advisory Council regards as ill-founded. It may be the only way to overcome the obstacles hindering the development of the Department's plans to which the Advisory Council refers.

for unless the resources at the disposal of the Department are very considerably expanded, only concentration of effort on carefully selected fields and objectives, and the elimination of some major activities, will permit the effective pursuit of the selected objectives and avoid increasing frustration, waste of effort and fruitless dissipation of resources. The Advisory Council appears to be aware of this danger, but it has failed so far to give such a lead, and the Committee of the Privy Council rejects the policy.

The dangers of the present situation are not confined to the Department. The Department has now an established and recognized place in the organization of research in Great Britain, and whatever criticism may from time to time have been made of the scale of its operations and the appropriateness of some of its research projects, there has been no suggestion that its activities should be seriously curtailed. Little has, in fact, been heard of late regarding the appropriateness of the research associations as a means for prosecuting industrial research compared with the research organization within industry. Indeed, it now seems to be accepted, even by those who lean to the adoption of the sponsored research institution of the Mellon Institute type as supplement or alternative, that they have a marked field of their own, not only in operational research but also in the dissemination of information and in technological training.

The general value of the Department's work is well attested by the present report alone; but so also is the extent to which its work is interlocked with the rest of the research effort of Great Britain and, to some extent, its provision for higher education. Proposals for expansion or curtailment or reorganization of the Department cannot be considered in isolation; this is well illustrated by the Department's relations with the universities. The Department makes very considerable grants over periods of years to the universities for special investigations. It also spends some £250,000 on grants to students and senior research awards at the universities; but it appears from the present report that the Department to some extent relies upon the universities to carry out investigations under contract which its existing establishments are unable to pursue. This is notable in radio research, for example, in hydraulics and in mechanical engineering, and in the present situation there would appear to be a distinct danger that the policy may be pushed too far. Sir John Stopford recently expressed concern that the large increase in the external public responsibilities of the universities since the Second World War might deflect university staffs from their primary duty of teaching and research. Sir John thought that the universities should reject the heavy responsibility of research enterprises too big for the limited resources of a university.

Others besides Sir John Stopford have expressed concern at the possible effect of sponsored research on university work; and the implications of this trend should be given more attention by the Advisory Council than appears from this present report. Allied to this question is that of the proper balance to be struck between fundamental research and *ad hoc* short-term investigations. That is never an easy decision, particularly when some of the *ad hoc* investigations and the testing work strengthen the contact between the Department's staff and industry. Nevertheless, it would appear from the Advisory Council's comments on radio research and some other activities that there is danger of testing work absorbing an undue proportion of the effort of some establishments. The possibility of transferring such testing work to a separate bureau or organization with no responsibilities for research appears to merit examination. If it could be effected, such a transfer would remove one factor which encourages an exaggerated view of the extent of the Department's true research effort.

That, and the relation of the Department's work to the general research effort of Great Britain and also to the universities, are matters to which the Lord President of the Council and his Committee should be addressing themselves with vision as well as urgency. On the disposition of the Department's own resources, the Advisory Council could do something more than reiterate its predecessor's recommendations for planned expansion. A more detailed and forceful exposition of the value of the Department's work to the nation seems also to be required.

Clearly, the Advisory Council cannot immediately survey the activities of all its establishments in the way that it has examined those of three of the research associations. It should not be impossible, however, to cover with reasonable speed and thoroughness in some such way those features of its work which in last year's report were singled out for special mention as in urgent need of expansion. If the case for such expansion were thus presented to the Lord President of the Council and to Parliament, backed by the Advisory Council to the extent of resignation or to the re-allocation of the present resources to other purposes where they could be more effectively used, it is hard to believe that the position would not be reconsidered by the government.

Last year's report raised the crucial issue of reasonable year-to-year financial flexibility for the Department, and the present report fully emphasizes its importance. That issue is, however, now completely over-shadowed by the fundamental one of the whole future of the Department. Whether its activities are to be expanded, reorganized or considerably curtailed can only be wisely determined in the light of a national policy for science and technology. It is to be hoped that the Advisory Council's present call for help will be noted by the Parliamentary and Scientific Committee and other bodies able to influence the government. The present unsatisfactory situation should be ended, and the future activities of the Department reviewed in the light of a policy taking full account of the nation's resources in materials and man-power. Only in the light of such a review and policy can wise decisions be made which will enable the Department to concentrate its resources on the approved objectives, in the confidence that those resources are adequate to the task, and that it can offer the conditions of service which will attract —and retain—scientists and technologists of the high calibre required.

PREHISTORIC AMERICA AND POLYNESIA

American Indians in the Pacific

The Theory behind the Kon-Tiki Expedition. By Thor Heyerdahl. Pp. xv+821+90 plates. (London: George Allen and Unwin, Ltd.; Stockholm: Bokförlaget Forum A.-B.; Oslo: Gyldendal Norsk Forlag, 1952.) 70*s.* net.

THOR HEYERDAHL is an enthusiast. His epic 'Kon-Tiki' raft-voyage across the eastern Pacific, enduring privation and risking death, was undertaken to support a theory. His latest book, massive and lavishly illustrated, presents the evidence for that theory, whole-heartedly, persuasively, and often uncritically.

The theory is ingenious. It is, briefly, that the evidence for the generally held idea of the Asiatic origin of the Polynesian people and Polynesian culture is quite inadequate, and that two streams from the American continent have been responsible. The first, Heyerdahl argues, went raft-borne from the Peruvian coast in pre-Inca times, approximately about A.D. 500. These were the people who provided the "Caucasian-like elements" of strongly-bearded, light-skinned, fair-haired folk mentioned in Polynesian tradition and by some early European voyagers. They were responsible, he holds, for introducing cotton, sweet potato, gourd and many other plants to Polynesia, and for many cultural items, notably the sculpture of huge anthropomorphic statues in stone, of which the best-known examples are on Easter Island. But, it is pointed out, the present-day Polynesians do not make much use of rafts—they are adept in the manufacture and use of canoes. Moreover, before Europeans came, they were ignorant of the loom, of pottery, of cereal cultivation and of other features characteristic of Central and South American cultures. Hence, Heyerdahl postulates a second stream of immigrants, a Kwakiutl-type of people arriving from Queen Charlotte Sound, British Columbia, where these items were lacking, about the beginning of the present millennium. It is these so-called "Maori-Polynesians" who are held to be responsible for the large canoe-hulls of Polynesia, and for many other cultural features, including adzes, rectangular plank houses, massive timber-carving, short striking-clubs, fire-walking and cannibalism.

The author builds up a case for Amerindian relationships and stimulus in Polynesia that is far stronger than any advanced hitherto. Among his most telling points are: the favouring effects of the major eastward movement of prevailing winds and currents; the sailing possibilities of the Peruvian balsa raft; the (so far) admitted American origin of the sweet potato and of the 'native' Polynesian cotton with its twenty-six haploid chromosomes; the lack of the *B* blood-group among Polynesians as against its prevalence in South-East Asia; and the striking superficial similarities and suggestive distribution of certain types of Polynesian and Amerindian sculpture. But much of what the author treats as proof will appear to many anthropologists, even to those with no axe of origins of their own to grind, as only surmise of more or less plausibility.

One difficulty is that much of the argument rests on seizing quite general similarities as significant of some kind of connexion. The division of the Indian society of the north-west Pacific coast into three separate social classes—aristocracy, commoners, slaves—is said to be "followed closely" by the Maori, the Society islanders and some other Polynesian groups, who "strictly adhered to the same division" (p. 141). As regards land tenure, it is stated that "the state was completely communistic among both the northwest Indians and the Maori-Polynesian tribes" (*ibid.*). This amateurish kind of expression is valueless in investigating relationships; it ignores basic elements in structure and organization. Moreover, comparisons which show differences are apt to be neglected. The Polynesians are stated to have had a system of patriarchal clan units, with marked analogy among the Kwakiutl, who "reckon descent usually in the father's sept, and *marry into some other*" (my ital., p. 141). Even granted the propriety of the "patriarchal clan" notion, which the complexities in both societies render dubious, it should be pointed out that on Heyerdahl's own quotation from Goddard, as well as according to data from Boas, the Kwakiutl are primarily exogamous, whereas the Polynesians are not.

Again, far too much reliance is placed on genealogies, myth and tradition in tracing connexions. Recent work in anthropology has shown that such memory material is to be interpreted primarily as a clue to contemporary social relationships; its value as a historical record is very limited. This caution is especially necessary if one attempts to use translations of Polynesian proper names. The many homophones to be found in Polynesian—and it does not appear that the author speaks any Polynesian dialect well—make it highly conjectural to assign a meaning to such a name unless one knows the circumstances in which the name was bestowed. The author translates, for example, *Tu-te-rangi-marama* as "Marama, the Sacred of the Heaven" (p. 722); *Mata-ki-te-rangi* as "Eyes Facing Paradise" (p. 756); and *Vaka-akau-uli* as "Steersman-of-log-craft" (p. 726). When we know that these could be also translated much more prosaically as "Tu of the bright sky", "Face to the sky", and "Canoe of dark wood", they lose their alleged importance as migration indicators. The various sun-god equations of the Polynesian Tangaroa with the Peruvian Kon, and of Tiki or Maui-tikitiki with Ticci are far-fetched. And to state that a connexion between a stone talisman, *mauri*, and the ocean-voyaging culture-hero Maui "cannot be proved, but is etymologically very possible" (p. 245), because early Polynesian voyagers are said to have taken such talismans with them in their canoes, is too casual.

In his anxiety to leave no loose ends, the author brushes negatives aside. The Polynesians had no pre-European cereals. Yet maize was a characteristic food-plant in the Peruvian area from which the author supposes them to have come. How did it escape them? By having been lost during the landing of the Amerindian craft through the surf on Polynesian reefs, or by having failed to give a successful crop after having been sown, he answers. But the question does not really interest him. The absence of pottery from Polynesia, too, attracts discussion only to demonstrate the lack of relation with South-East Asia, whereas no very cogent reasons are given to explain why pottery should not have been brought from Peru, where it had reached a high state of development by the time that the ancestors of the Polynesians are said to have left.

Finally, the author rather overdoes his argument about the virtual impossibility of the ancient Poly-

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Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1
Telephone Number: Regent 3891

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GOVERNMENT SCIENTIFIC RESEARCH IN GREAT BRITAIN

DURING the past year there has been evident in Parliament, from time to time, a desire for fuller information regarding the work of the Department of Scientific and Industrial Research. While strong support was forthcoming in a debate in the House of Commons last June for the Advisory Council's plea, in its last year's report, for more continuity in the financial support of the Department's work, members of Parliament are manifestly and rightly concerned to satisfy themselves that the considerable sums concerned, approaching £6 millions in the estimates for 1953–54, are expended wisely and without waste. There has been little criticism of the general basis of the Department's plans to meet post-war needs, though some concern has been expressed at the delay in giving full effect to those plans; and, according to the Department's report for 1950–51, this was even then causing grave anxiety to the Advisory Council.

The report of the Department for the year 1951–52, which has now been published (see p. 716 of this issue), while making a praiseworthy effort to provide the detailed information which Parliament is seeking, is marked by the same note. "Nothing," writes the Advisory Council, "has since occurred to mitigate our anxiety. In fact, we find ourselves reviewing the relation between our scientific needs and our scientific resources with steadily deepening concern." The difficulty of drawing a balance between advisory and *ad hoc* work on one hand, and longer range research on the other, is recognized; but while agreeing with those who, like Sir Henry Tizard, stress the utmost importance of widely disseminating and using to the full existing information, the Advisory Council points to evidence that deficiencies in knowledge have often to be made good before fully satisfactory answers can be found to some of the problems and inquiries put to the Department. These deficiencies will become more serious as industry becomes more conscious of the help to be gained from science, unless the reservoir of scientific knowledge from which answers are derived is enlarged by further research.

"We and our colleagues on the Advisory Boards," continues the Advisory Council, "are already deeply concerned at the inadequacy of the effort the D.S.I.R. Establishments can devote to the longer range research. Basic research is hardly worth doing if the effort that can be devoted to it is insufficient to secure steady progress, and the suggestions made from time to time to reduce the present meagre effort appear to us to be ill-founded. We remain firmly of the view that there is no alternative to the planned expansion of the D.S.I.R. that our predecessors recommended six years ago."

In spite of this comment, however, the Advisory Council gives little or no information as to the present position of what are described in its previous report as the most urgent items in the Department's building programme. After a delay of twelve months due to the standstill on civil building work, work was begun on the second new laboratory building for mechanical

engineering research in May 1952, but construction of the Heat Transfer and Creep Laboratories has still not begun. While the expenditure in this field increased from £137,566 in 1950–51 to £267,434 in 1951–52, much work has still to be carried out at the National Physical Laboratory, or at the universities under contract—and this when the industries which the new laboratory will serve are responsible in the aggregate for exports to the value of £750 millions a year and play the most important part in rearmament.

While such slender progress is being made in discharging the Department's obligation to develop the new Mechanical Engineering Research Laboratory as the chief national centre for basic research in all branches of mechanical engineering, progress in the development of the Hydraulics Research Station at Wallingford has been equally slow. The damage done to the coastal defences of Britain by the high tides and gales early this year points to the danger of neglect in this field and the probable cost to the nation of delay. The work of Lord Waverley's committee would probably be greatly assisted had this Station already been fully in operation. Apart from this, as noted in last year's report, important contracts have been lost to Britain through the absence of a centre with facilities for basic research and experiments with models on coast erosion and accretion, the effect of dredging and drainage schemes on estuaries and rivers, and the design of dock and harbour works so as to avoid silting. Experimental work in Britain is still in its preliminary stages, and relies on the National Physical Laboratory and the Imperial College of Science and Technology. Nor does the report indicate whether or not there has been further delay in letting the contract for the erection of the new Water Pollution Research Station at Stevenage or acquiring a site for a new Road Research Laboratory. Design work on the project for the new tank and water-tunnel which was stopped in October 1951 has, however, been resumed; but it appears that, since the project is still "subject to review in the light of the current economic situation", the importance of an up-to-date 'tank' and ancillary equipment for studying the design of ships' hulls is not fully appreciated, although Britain still constructs one-third of the world's shipping.

Some attention is given in the present report to the remaining two matters in the building programme which were stressed last year as specially urgent—the Radio Research Station and the Building Research Station. The hope is expressed that the construction of the permanent buildings on the site at Slough, referred to in the previous report, will be commenced in 1953, but meanwhile the work has to continue partly in huts and partly at the National Physical Laboratory. Apart from a small amount of fundamental research in progress at two universities, with support from the Department of Scientific and Industrial Research, the Radio Research Station is the only establishment in Great Britain doing fundamental work in this field.

The Radio Research Station was one of the three establishments specially visited by the Advisory Council during the past year, and it was noted that at present about half the staff of the organization is engaged in work on propagation and about one-third on research on properties of materials used in radio construction. The Council was impressed by the unanimous opinion which it encountered that, while increased facilities are urgently needed, so that more effort can be directed to problems of importance to the manufacturing side of the industry, this effort should not be obtained by curtailing research on propagation. It was also regarded as essential, in the present stage of the development of radio forecasting, that those engaged in it and in organizing ionospheric observations should continue to work in close conjunction with those carrying out research on propagation. Nevertheless, the Summary of Expenditure appended to the report shows that expenditure on radio research was reduced by some 20 per cent during 1951–52.

We refer later to two features of the Department's work which are well illustrated by the position of the Radio Research Station, and pass to the work of the Building Research Station. The Advisory Council was also impressed by the work of this Station and its practical value to the building and contracting industries. It stresses particularly the investigation of the causes of defects in buildings; the work on thermal and acoustical insulation of buildings and on heating systems; and the work on alternative methods of construction, which has saved the industry much wasted effort. The Station has evolved a cheaper and better mortar, now in general use, and has shown how substantial economy in cement can be achieved in concrete and in external rendering. Current work on the causes of heavy maintenance costs of buildings and on eliminating unnecessary handling of materials during construction is also noted, and an experimental study of the planning of dwellings conducted in co-operation with housewives has led to modifications in the planning and equipping of kitchens which should result in economy in cost and increased satisfaction to the housewife.

It appears that the industry is taking more notice of the results of this work, which are being applied more widely. The Advisory Council is satisfied that, to meet the increasing needs of the industry and to economize in man-power, it is essential that the various branches of the work of the Station should be brought together on a single site with as little delay as possible. The report gives, however, no indication as to the progress made in the reconstruction and extension of the Building Research Station, of which the previous report had stated: "far more remains to be done, including the acquisition of additional land".

In view of this, it is surprising to find in the report of the Committee of the Privy Council that the resources available for building research are to be curtailed. There may be some substance in the view that the staff employed in building research in October 1951 represented an excessive proportion of the restricted total staff available for the Department, and the Committee of the Privy Council points out that when the reduction has been made the non-industrial staff for building research is more than one-seventh of the total for all the Department's

research establishments and more than one-and-a-half times as large as that of any other establishment except the National Physical Laboratory. In the estimates for 1953–54, the actual reduction in staff is given as 39 on the 1952–53 figure of 577, and the expenditure as £366,790, compared with £378,904 for 1952–53. Even more surprising is the contrast between this decision and the firmness with which the Government holds to its programme of building three hundred thousand houses a year.

Even if the belief that at the present time this housing programme represents too large a proportion of the country's economic resources is unfounded, it is scarcely consistent with the Government's programme of eliminating waste to hold up investigations into how to build houses more efficiently and cheaply. Doubts as to the wisdom of the economies which the Committee of the Privy Council or the Advisory Council proposes are further suggested by the reference in the latter's report to the Geological Survey. The Survey furnishes reliable advice to industry and to government departments on such matters as mineral deposits, water supplies and the planning of mining operations, and in connexion with the execution of many civil engineering projects. Such advice is usually based on the geological map, on which the geologist records the results of his work; present-day demands for geological information require the compilation of such maps on a scale of six inches to the mile for most areas of Great Britain. When the Department of Scientific and Industrial Research prepared its post-war plans, it was estimated that some 33,000 square miles of Great Britain had not been surveyed on this scale, and the plan of expansion for the Geological Survey then approved provided for the completion of the mapping programme in about thirty years. At the present rate of progress it will take more than one hundred years to complete, and the Advisory Council's plea for additional staff for field-work, and its reference to the delay in dealing with inquiries caused by this slow progress, should be viewed also against the disparity between the expenditure on the Geological Survey and that, for example, on the corresponding surveys of the U.S.S.R. or the U.S.A. Nor would the increase in the estimated expenditure on the Survey to £176,706 in the 1953–54 Estimates, compared with £164,817, appear likely either to increase appreciably the rate of progress or diminish that disparity; expenditure in the United States before the Second World War was already £1 million compared with £70,000 in Great Britain.

Apart from expenditure on building research and on the National Physical Laboratory (reduced from £721,855 in 1952–53 to £666,785 in 1953–54), the 1953–54 estimates for the Department of Scientific and Industrial Research show slight increases over the estimates for 1952–53; only for radio research is there a significant increase—from £14,903 to £74,649, with an increase of 87 in the staff, to a total of 112. The impression derived from the estimates in the light of this report is of trifling and indecision, and a failure to grapple with the real issues. The resources of the Department appear to be spread too thinly over too wide a range of activities, and the Advisory Council appears to be reluctant to take the ruthless action which would really bring home to the nation and to the government the price which may be paid for niggardliness where research is concerned.

But it is not merely that proposals, such as the Committee of the Privy Council makes, for cancelling authorized vacancies in staff, are as likely to cause waste as economy: there is to be sensed something of a rift in outlook between the Committee of the Privy Council and the Advisory Council. It is hard to reconcile the former's decision, though reluctant, "that some contribution must be made by the Department in the general economies that are being made in the government service as a whole", with the "steadily deepening concern" of the Advisory Council. Nor does the effect of this decision "not to eliminate any major plan or activity, but to slow down some work and to arrest, for the time being, most of the planned expansions of activities" easily harmonize with the Advisory Council's firm view that "there is no alternative to the planned expansion of the Department of Scientific and Industrial Research that our predecessors recommended six years ago". Elsewhere, in concluding its report, the Advisory Council adds: "We are, however, becoming more and more convinced that science will never be adequately used in this country until many more scientists and technologists are employed throughout industry, not omitting the direction and management". Ostensibly the words are directed at industry and call for wider provision for higher technological education; but the Advisory Council could equally be aiming them higher.

That passage, however, concludes a discussion on technical information services and the measures being taken by the Advisory Council to stimulate the utilization of existing knowledge by industry. Reference is made here to the survey of technological resources and the requirements of industrial firms in the north-west of Britain now being conducted by the Manchester Joint Research Council; but the summary of expenditure this year does not disclose the expenditure on intelligence. With the Committee of the Privy Council's decision to seek its main economies, after building research, in the headquarters office, the omission may or may not be significant. The estimates for 1953–54 show a reduction of £14,292 in headquarters expenditure; but whether or not that has curtailed the activities of the intelligence division, the possibility of some degree of overlapping may merit examination; thus there is no clear justification in the report for the grant of £15,000 during the past three years to the Association of Special Libraries and Information Bureaux.

To suggest that major and minor activities of the Department should be rigorously scrutinized and ruthlessly pruned where their continuance on the existing scale cannot be justified in the national interest is not to advocate the reductions in the present effort which the Advisory Council regards as ill-founded. It may be the only way to overcome the obstacles hindering the development of the Department's plans to which the Advisory Council refers,

for unless the resources at the disposal of the Department are very considerably expanded, only concentration of effort on carefully selected fields and objectives, and the elimination of some major activities, will permit the effective pursuit of the selected objectives and avoid increasing frustration, waste of effort and fruitless dissipation of resources. The Advisory Council appears to be aware of this danger, but it has failed so far to give such a lead, and the Committee of the Privy Council rejects the policy.

The dangers of the present situation are not confined to the Department. The Department has now an established and recognized place in the organization of research in Great Britain, and whatever criticism may from time to time have been made of the scale of its operations and the appropriateness of some of its research projects, there has been no suggestion that its activities should be seriously curtailed. Little has, in fact, been heard of late regarding the appropriateness of the research associations as a means for prosecuting industrial research compared with the research organization within industry. Indeed, it now seems to be accepted, even by those who lean to the adoption of the sponsored research institution of the Mellon Institute type as supplement or alternative, that they have a marked field of their own, not only in operational research but also in the dissemination of information and in technological training.

The general value of the Department's work is well attested by the present report alone; but so also is the extent to which its work is interlocked with the rest of the research effort of Great Britain and, to some extent, its provision for higher education. Proposals for expansion or curtailment or reorganization of the Department cannot be considered in isolation; this is well illustrated by the Department's relations with the universities. The Department makes very considerable grants over periods of years to the universities for special investigations. It also spends some £250,000 on grants to students and senior research awards at the universities; but it appears from the present report that the Department to some extent relies upon the universities to carry out investigations under contract which its existing establishments are unable to pursue. This is notable in radio research, for example, in hydraulics and in mechanical engineering, and in the present situation there would appear to be a distinct danger that the policy may be pushed too far. Sir John Stopford recently expressed concern that the large increase in the external public responsibilities of the universities since the Second World War might deflect university staffs from their primary duty of teaching and research. Sir John thought that the universities should reject the heavy responsibility of research enterprises too big for the limited resources of a university.

Others besides Sir John Stopford have expressed concern at the possible effect of sponsored research on university work; and the implications of this trend should be given more attention by the Advisory Council than appears from this present report. Allied to this question is that of the proper balance to be struck between fundamental research and *ad hoc* short-term investigations. That is never an easy decision, particularly when some of the *ad hoc* investigations and the testing work strengthen the contact between the Department's staff and industry. Nevertheless, it would appear from the Advisory Council's comments on radio research and some other activities that there is danger of testing work absorbing an undue proportion of the effort of some establishments. The possibility of transferring such testing work to a separate bureau or organization with no responsibilities for research appears to merit examination. If it could be effected, such a transfer would remove one factor which encourages an exaggerated view of the extent of the Department's true research effort.

That, and the relation of the Department's work to the general research effort of Great Britain and also to the universities, are matters to which the Lord President of the Council and his Committee should be addressing themselves with vision as well as urgency. On the disposition of the Department's own resources, the Advisory Council could do something more than reiterate its predecessor's recommendations for planned expansion. A more detailed and forceful exposition of the value of the Department's work to the nation seems also to be required.

Clearly, the Advisory Council cannot immediately survey the activities of all its establishments in the way that it has examined those of three of the research associations. It should not be impossible, however, to cover with reasonable speed and thoroughness in some such way those features of its work which in last year's report were singled out for special mention as in urgent need of expansion. If the case for such expansion were thus presented to the Lord President of the Council and to Parliament, backed by the Advisory Council to the extent of resignation or to the re-allocation of the present resources to other purposes where they could be more effectively used, it is hard to believe that the position would not be reconsidered by the government.

Last year's report raised the crucial issue of reasonable year-to-year financial flexibility for the Department, and the present report fully emphasizes its importance. That issue is, however, now completely over-shadowed by the fundamental one of the whole future of the Department. Whether its activities are to be expanded, reorganized or considerably curtailed can only be wisely determined in the light of a national policy for science and technology. It is to be hoped that the Advisory Council's present call for help will be noted by the Parliamentary and Scientific Committee and other bodies able to influence the government. The present unsatisfactory situation should be ended, and the future activities of the Department reviewed in the light of a policy taking full account of the nation's resources in materials and man-power. Only in the light of such a review and policy can wise decisions be made which will enable the Department to concentrate its resources on the approved objectives, in the confidence that those resources are adequate to the task, and that it can offer the conditions of service which will attract —and retain—scientists and technologists of the high calibre required.

PREHISTORIC AMERICA AND POLYNESIA

American Indians in the Pacific

The Theory behind the Kon-Tiki Expedition. By Thor Heyerdahl. Pp. xv+821+90 plates. (London: George Allen and Unwin, Ltd.; Stockholm: Bokförlaget Forum A.-B.; Oslo: Gyldendal Norsk Forlag, 1952.) 70s. net.

THOR HEYERDAHL is an enthusiast. His epic 'Kon-Tiki' raft-voyage across the eastern Pacific, enduring privation and risking death, was undertaken to support a theory. His latest book, massive and lavishly illustrated, presents the evidence for that theory, whole-heartedly, persuasively, and often uncritically.

The theory is ingenious. It is, briefly, that the evidence for the generally held idea of the Asiatic origin of the Polynesian people and Polynesian culture is quite inadequate, and that two streams from the American continent have been responsible. The first, Heyerdahl argues, went raft-borne from the Peruvian coast in pre-Inca times, approximately about A.D. 500. These were the people who provided the "Caucasian-like elements" of strongly-bearded, light-skinned, fair-haired folk mentioned in Polynesian tradition and by some early European voyagers. They were responsible, he holds, for introducing cotton, sweet potato, gourd and many other plants to Polynesia, and for many cultural items, notably the sculpture of huge anthropomorphic statues in stone, of which the best-known examples are on Easter Island. But, it is pointed out, the present-day Polynesians do not make much use of rafts—they are adept in the manufacture and use of canoes. Moreover, before Europeans came, they were ignorant of the loom, of pottery, of cereal cultivation and of other features characteristic of Central and South American cultures. Hence, Heyerdahl postulates a second stream of immigrants, a Kwakiutl-type of people arriving from Queen Charlotte Sound, British Columbia, where these items were lacking, about the beginning of the present millennium. It is these so-called "Maori-Polynesians" who are held to be responsible for the large canoe-hulls of Polynesia, and for many other cultural features, including adzes, rectangular plank houses, massive timber-carving, short striking-clubs, fire-walking and cannibalism.

The author builds up a case for Amerindian relationships and stimulus in Polynesia that is far stronger than any advanced hitherto. Among his most telling points are: the favouring effects of the major eastward movement of prevailing winds and currents; the sailing possibilities of the Peruvian balsa raft; the (so far) admitted American origin of the sweet potato and of the 'native' Polynesian cotton with its twenty-six haploid chromosomes; the lack of the *B* blood-group among Polynesians as against its prevalence in South-East Asia; and the striking superficial similarities and suggestive distribution of certain types of Polynesian and Amerindian sculpture. But much of what the author treats as proof will appear to many anthropologists, even to those with no axe of origins of their own to grind, as only surmise of more or less plausibility.

One difficulty is that much of the argument rests on seizing quite general similarities as significant of some kind of connexion. The division of the Indian society of the north-west Pacific coast into three separate social classes—aristocracy, commoners, slaves—is said to be "followed closely" by the Maori, the Society islanders and some other Polynesian groups, who "strictly adhered to the same division" (p. 141). As regards land tenure, it is stated that "the state was completely communistic among both the northwest Indians and the Maori-Polynesian tribes" (*ibid.*). This amateurish kind of expression is valueless in investigating relationships; it ignores basic elements in structure and organization. Moreover, comparisons which show differences are apt to be neglected. The Polynesians are stated to have had a system of patriarchal clan units, with marked analogy among the Kwakiutl, who "reckon descent usually in the father's sept, and *marry into some other*" (my ital., p. 141). Even granted the propriety of the "patriarchal clan" notion, which the complexities in both societies render dubious, it should be pointed out that on Heyerdahl's own quotation from Goddard, as well as according to data from Boas, the Kwakiutl are primarily exogamous, whereas the Polynesians are not.

Again, far too much reliance is placed on genealogies, myth and tradition in tracing connexions. Recent work in anthropology has shown that such memory material is to be interpreted primarily as a clue to contemporary social relationships; its value as a historical record is very limited. This caution is especially necessary if one attempts to use translations of Polynesian proper names. The many homophones to be found in Polynesian—and it does not appear that the author speaks any Polynesian dialect well—make it highly conjectural to assign a meaning to such a name unless one knows the circumstances in which the name was bestowed. The author translates, for example, *Tu-te-rangi-marama* as "Marama, the Sacred of the Heaven" (p. 722); *Mata-ki-te-rangi* as "Eyes Facing Paradise" (p. 756); and *Vaka-akau-uli* as "Steersman-of-log-craft" (p. 726). When we know that these could be also translated much more prosaically as "Tu of the bright sky", "Face to the sky", and "Canoe of dark wood", they lose their alleged importance as migration indicators. The various sun-god equations of the Polynesian Tangaroa with the Peruvian Kon, and of Tiki or Maui-tikitiki with Ticci are far-fetched. And to state that a connexion between a stone talisman, *mauri*, and the ocean-voyaging culture-hero Maui "cannot be proved, but is etymologically very possible" (p. 245), because early Polynesian voyagers are said to have taken such talismans with them in their canoes, is too casual.

In his anxiety to leave no loose ends, the author brushes negatives aside. The Polynesians had no pre-European cereals. Yet maize was a characteristic food-plant in the Peruvian area from which the author supposes them to have come. How did it escape them? By having been lost during the landing of the Amerindian craft through the surf on Polynesian reefs, or by having failed to give a successful crop after having been sown, he answers. But the question does not really interest him. The absence of pottery from Polynesia, too, attracts discussion only to demonstrate the lack of relation with South-East Asia, whereas no very cogent reasons are given to explain why pottery should not have been brought from Peru, where it had reached a high state of development by the time that the ancestors of the Polynesians are said to have left.

Finally, the author rather overdoes his argument about the virtual impossibility of the ancient Poly-

nesians making headway against the trade winds and the prevailing currents—the "one-way ocean escalator from Peru westwards". Elsdon Best and S. Percy Smith have pointed out three factors which are relevant for voyages in the opposite direction. First, the prevailing winds do not prevail always. Winds, often of considerable strength, blow for significant periods from west-north-west or north-west or even south-west. Secondly, Polynesian canoes could beat to some extent against a contrary wind, helped by the long steering-oar. Thirdly, in a contrary wind that was not too strong the Polynesian often paddled his craft. Moreover, the effects of the equatorial counter-current, variable and weak as it often is, are not to be dismissed. Without decrying the author's magnificent achievement on his raft, it may be fairly said to have involved seamanship rather than sailing skill, and one receives the impression that he consistently undervalues what an oceanic sailing canoe can do.

Despite its huge amount of material, the book is ably written, with a lively style, and the argument is cleverly presented. Provided the reader is prepared for an all-out statement rather than the dispassionate examination of the case, he will be interested and even entertained. But also he should remember that the problems discussed are not those which most anthropologists regard as most important in the Pacific to-day.

RAYMOND FIRTH

SCIENTIFIC THOUGHT OF THE EARLY NINETEENTH CENTURY

Genesis and Geology

A Study in the Relations of Scientific Thought, Natural Theology and Social Opinion in Great Britain, 1790–1850. By Charles Coulston Gillispie. (Harvard Historical Studies published from the income of the Henry Warren Torrey Fund, Vol. 58.) Pp. xv+315. (Cambridge, Mass.: Harvard University Press, 1951.) 30*s*. net.

THE author of the book under notice is not a geologist, or even a scientist, but is assistant professor of history at Harvard. "Genesis and Geology" is rather a forbidding title, reminiscent of a type of book published in considerable numbers and widely read during the first half of the nineteenth century. It recalls, for example, the Rev. John Pye Smith's "Relations between the Holy Scriptures and Some Parts of Geological Science", published in 1839, which attained five editions. In fact, Prof. Gillispie's book is an interesting, well-written, scholarly and at times even amusing study of the relations between scientific thought, natural theology and social opinion in Britain between the years 1790 and 1850.

Its publication arose out of the author's special interest, as a historian, in the nineteenth century, and his belief that issues stemming from the growth and dissemination of science may be approached by the historian as problems of intellectual history. Such studies he regards as desirable for the understanding of science as well as history. Because so much has been written about the period following the publication of Darwin's "Origin of Species", Prof. Gillispie concluded it would be more profitable to examine the preceding half-century, a period when the relation of science to religious beliefs was very much a matter of public concern. As a result, inevitably, he found himself forced to study the development of geology, rather than biology, for that was the golden age of geology. It was then the most popular science with the British public, with many followers on the Continent, and in the United States, too. Moreover, the period covered encompassed the publication of two outstanding geological classics, Hutton's "Theory of the Earth" (1795) and Lyell's "Principles of Geology" (1830–33). At about this time, however, some well-known geologists issued works the titles of which showed that they still had no difficulty in reconciling the new geology with the Mosaic account of Creation. A well-known example is Dean Buckland's "Reliquiæ Diluvianæ, or observations on the organic remains in caves . . ., and on other geological Phenomena attesting the action of the Universal Deluge" (1823). In addition, numerous works by naturalists with little or no claim to eminence appeared, with the definite object of reconciling the latest geological views with religious beliefs. An example is the book by the Rev. John Pye Smith, to which reference has been made above. Finally, the publication of Robert Cambers's "Vestiges of Creation" (1844) and Hugh Miller's counterblast, "Footsteps of the Creator" (1847), formed a link with the Darwinian period.

The excitement caused by the publication of the "Origin of Species" was not new in kind. Earlier discoveries, particularly in geology, had seriously challenged not only the literal interpretation of the Book of Genesis, but also the traditional and widely held belief that Providence controls the order of Nature to fulfil a divine purpose. The "Origin" added fuel to a fire already burning.

Here, then, is a book to be read especially by all who wish to appreciate the scientific and social background of the half-century or so preceding the publication of Darwin's "Origin of Species". It is carefully documented and includes, as well as upwards of six hundred text references, a bibliographical essay. It should also be consulted by geologists interested in the history of their subject, more especially because very many of the sources noted will not be found in standard histories of the subject.

V. A. EYLES

IMPACT OF MAN ON BRITISH WILD LIFE

The Changing Wild Life of Britain

By H. L. Edlin. Pp. viii+184+36 plates. (London: B. T. Batsford, Ltd., 1952.) 21*s*. net.

THE wild life of Britain has been subjected to constant changes from the earliest times through the influence of man, who has introduced new plants and animals, driven others away, and altered the environment of those that have survived his interference. The dominating factor in the life of any wild animal in Britain to-day is its relations to man; "running parallel with the social, agricultural and industrial revolution of our human society, there has been a gradual change in the wild life of the countryside, which is still far from ended. Every change in methods of husbandry, sporting customs, or even the ownership of land, has aided certain organisms and upset others". This book deals with some of the

more obvious changes that have taken place in the British flora and vertebrate fauna.

About two-thirds of the book is devoted to the fauna, mainly the mammals and birds, and the rest to the flora. Four chapters are given to mammals: the deer, the carnivores, the rodents, and the semi-domesticated cattle, sheep, goats and ponies that have free range over some of the moors and mountains in Britain—the last a chapter of much interest. The probable origin of these animals, and of some of the domestic breeds, is discussed, and the enormous influence that sheep-grazing has had on the character of the British flora and fauna is emphasized. "The implications to the naturalist are obvious—he will seek in vain for 'natural' vegetation over most of the British Isles; what he will find will be sheep induced, or at least sheep influenced, vegetation."

The section on birds points out that, although several species have been unable to withstand changed conditions and are no longer British breeding birds, only one, the great auk, has become extinct. On the other hand, many introduced species, especially among the waterfowl, have now become naturalized and are established members of the fauna.

The story of the flora is one of continual enrichment; only a few rarities have been lost, but scores of ornamental plants, weeds, and even forest trees have been introduced deliberately or by accident. The account of the introduced trees is particularly well done, as would be expected from the author's professional connexion with forestry.

The book admirably succeeds in its purpose of giving a survey of the endless changes wrought by man upon his surroundings. It is full of information presented in an attractive form; it is well written, and illustrated with many good photographs. The text is also embellished with numerous figures, but many of the reproductions of Bewick's wood engravings have, unfortunately, been enlarged and printed on paper too coarse to do justice to the delicacy of the originals. The more open woodcuts taken from "Matthiolus" to illustrate the plants are much more successful.

In a book of this nature that covers so wide a field in such detail there are bound to be some points on which a carping critic might check the author. But they are minor matters; the book can be warmly recommended to all naturalists.

L. Harrison Matthews

CONFORMAL REPRESENTATION

Conformal Mapping

By Prof. Zeev Nehari. (International Series in Pure and Applied Mathematics.) Pp. viii+396. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 64*s*.

Conformal Representation

By C. Carathéodory. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 28.) Second edition. Pp. ix+115. (Cambridge: At the University Press, 1952.) 12*s*. 6*d*. net.

CONFORMAL representation is a many-sided subject, of interest to geographers, physicists, mathematicians and engineers. It started with problems of mapping, but developed into the theory of functions of a complex variable. Valuable contributions were made by Riemann, who stated the fundamental theorem that any simply connected domain can be conformably mapped on a circle. His proof was based on Dirichlet's Principle and used intuition to infer the existence of a function with certain properties. Another proof is based on boundary-value problems and the Green's function. Modern writers prefer a third method, using only the theory of functions. It is a great merit of Prof. Z. Nehari that in his book, "Conformal Mapping", he has combined an account of modern methods with a return to the spirit of Riemann, and has written for the physicist and engineer as well as for the mathematician. To make the book self-contained except for a knowledge of calculus, the first four chapters give an account of harmonic functions, analytic functions, the complex integral calculus, and families of analytical functions. The chapters are stated (not quite convincingly) to be suitable for those with no previous knowledge of these subjects. The preliminary informal discussion of Montel's normal families in Chapter 4, showing why the investigation is necessary, is admirable. These introductory chapters occupy about one-third of the book. Chapter 5 starts with the mapping properties of analytical functions, the 'linear' (or bilinear) transformation, and Schwarz's lemma, and then proves the fundamental theorem. Chapter 6 gives the mapping of certain special functions, including elliptic and elliptic modular functions. Chapter 7 deals with the conformal mapping of multiply-connected domains, including a careful treatment of the Green's function and Dirichlet's Principle, of which a preliminary account was given in Chapter 1. The book concludes with an index, but no bibliography or references to original papers. There are many problems and exercises in each chapter.

A few points for criticism can be made. The statement (p. 32) that the results in the previous sections concerning harmonic functions "are true regardless of whether the domains in question are simply-connected or multiply-connected" is open to doubt. The conditions for which Cauchy's integral theorem are applied (p. 183) do not seem to be included in those for which it is proved (pp. 84–8). The treatment of the Schwarz–Christoffel formula (pp. 189–198) and of the Joukowsky aerofoil profile (p. 271) might be improved by the addition of references from which the reader could obtain further details. However, as a whole, the book is very good.

The first edition of Prof. C. Carathéodory's excellent tract on "Conformal Representation" appeared in 1932. The first three chapters gave a simple account, suitable for beginners, of the 'Möbius' (or bilinear) transformation, non-Euclidean geometry and elementary transformations. The remaining four chapters were much more advanced and dealt with the fundamental theorem and related topics by the most refined modern methods, eliminating all traces of the early approaches and, in particular, of the physical ideas by which Riemann was so much influenced. To a beginner such a treatment may appear artificial, but the advanced student can realize its merits.

The present second edition, of which the manuscript was completed by the author before his death in 1950, contains an excellent extra chapter on the general theory of uniformization, which uses the method of van der Waerden to prove the celebrated theorem of Poincaré and Koebe. The bibliography and notes have been rewritten and form a valuable guide to further reading. H. T. H. Piaggio

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT FOR THE YEAR 1951–52

THE report of the Department of Scientific and Industrial Research for the year 1951–52* includes a brief covering report from the Committee of the Privy Council, over Lord Salisbury's signature, and the thirty-seventh annual report of the Advisory Council, signed by Sir Ian Heilbron, together with the usual summary of work carried out by the various research stations and boards and research associations. The appendixes include a classified list of departmental publications issued during the year, besides lists of assessors to the Advisory Council and of members of the research boards of the Department, of research associations and of grants for special investigations in progress during the year. While the report is an indispensable work of reference on the activities of the Department and is a very readable account of what Britain is getting for the £6 millions provided for these activities in the 1953–54 estimates, with its rising price the report is less than ever a popular account but rather one addressed strictly to the scientific and industrial world.

The gross expenditure of the Department for the year ended March 31, 1952, was £5,452,165, as against £5,007,822 in the previous year; this was reduced by receipts from various sources to £4,956,819, the net increase on 1950–51 being £402,397, and on 1949–50, £1,033,037. The staff of all grades employed in the Department on October 1, 1952, was 4,035 (including 149 part-time), a decrease of 53 compared with the previous year. The largest single item of expenditure was, as usual, the annual grants to research associations, totalling £1,334,863, besides special grants of £52,624. Gross expenditure on the National Physical Laboratory was £840,439, reduced by receipts to £559,335 net. Grants for special researches amounted to £313,693, a decrease of £74,209; and the list of grants for special researches in progress during the year ending September 30, 1952, is of interest in connexion with the recent argument in favour of giving the Department at least the right to carry over unspent money from year to year, if not to extend to the Department the principle of quinquennial grants so as to stabilize its budgetary expectations on a longer-term basis. The majority of the grants listed are spread over a period of years, the largest five being £487,500 to the University of Liverpool for the construction of a 400-MeV. proton synchrocyclotron for nuclear research, £317,700 to the University of Glasgow for the construction of a 300-MeV. electron synchrotron for nuclear research, £231,500 to the University of Birmingham for the construction of a 1,000-MeV. proton synchrotron for nuclear physics research, £191,000 to the University of Oxford for construction of a 140-MeV. proton synchrotron for nuclear physics, and £168,000 to the University of Manchester for radio-astronomy covering from four to six years.

Grants to students amounted to £251,241 net, an increase of £14,529. Net expenditure on mechanical engineering was £267,434, an increase of £129,868; on the Geological Survey and Museum £196,552, an increase of £38,351; on road research £273,259, an increase of £29,277; on the Chemical Research Laboratory £96,523, an increase of £22,346; on hydraulics £53,082, an increase of £27,084; and on fuel research £219,154, an increase of £15,223. Net expenditure of £498,123 on building research, £22,805 on fire research, £185,949 on food investigation, £97,288 on forest products research, £51,632 on pest infestation, and £55,842 on water pollution was of the same order but slightly higher than during 1950–51, while expenditure on radio research was £23,016, a decrease of £6,590. Net expenditure on headquarters administration, etc., was £208,029, and on overseas liaison £66,086, while research contracts again decreased to £34,310 compared with £70,606 during 1950–51. Expenditure on the Provision of Technical Equipment under American Aid increased from £498 to £97,433.

The number of students-in-training was 923, compared with 910 during 1950–51, and, of these, 384 were new. The senior research awards were thirteen in number, of which nine were new, compared with ten in 1950–51, and thirty-eight new grants for special investigations brought the total of such grants to ninety-one, compared with ninety-five in 1950–51. The preponderance in chemistry and physics continued: of senior research awards, five were in chemistry, six in physics and two in engineering; and of the grants for special investigations, twenty-six were in chemistry, forty-one in physics and fourteen in engineering. Of the grants to students, 390 were in chemistry, 276 in physics, 73 in biology, 71 in engineering, 48 in mathematics and astronomy, 38 in geology and mineralogy, and 27 in metallurgy.

The note of anxiety which characterized the report for last year recurs, both in the report of the Committee of the Privy Council and in that of the Advisory Council itself. The reasons for this anxiety and the implications of the measures adopted to meet the financial situation are discussed elsewhere (see p. 709). Apart from this, the most important feature of the former report is the intimation of the decision, in conjunction with the Committee of the Privy Council for Medical Research, and with the subsequent approval of the Lord President of the Council, to appoint two joint committees to study human problems in industry (see *Nature*, April 18, p. 684). The first, the Committee on Individual Efficiency in Industry, will be asked to keep under review the progress of knowledge bearing on the technical efficiency of the individual in industry, advise on general policy in research in this field, direct attention to gaps, make recommendations for filling them, and to consider and report from time to time on the requirements for the training of research workers and technologists in this field. The second, the Committee on Human Relations in Industry, will examine current activities concerning the study of human relations in industry and direct attention to problems of special timeliness and promise on which research might be undertaken or supported by the Department of Scientific and Industrial Research and the Medical Research Council, or other bodies.

The membership of these Committees was announced in the House of Commons on March 24, and the reasons for the decision to appoint the Committees are briefly indicated in a section of the Advisory Council's report. Fundamentally, they arise out of the recognition that the successful introduction of new methods and new equipment depends

* Department of Scientific and Industrial Research. Report for the Year 1951–52. (Cmd. 8773.) Pp. 293. (London: H.M. Stationery Office, 1953.) 8s. net.

largely on human factors and that, while the responsibilities of the Medical Research Council and the Department of Scientific and Industrial Research in such matters as affect individual efficiency can be quite clearly defined, a joint approach to the whole field offers real advantage. Human relations are less tangible and more difficult to handle, and both Councils believe that a joint committee, with the first task of reviewing what is being done in this field in Britain and abroad, offers the best means of selecting the most promising lines of work for support by either Council.

Apart from this, and from the financial situation of the Department, the chief features of the Advisory Council's report are the comments on the increasing interest of the research associations in operational research, on the recommendations of the Cremer report regarding research in chemical engineering, on technical information services, and on the Advisory Council's visits during the year to establishments of the Department. These included the Geological Survey and Museum of Practical Geology at South Kensington, the Building Research Station and the Radio Research Station; and the Advisory Council once again expressed itself as being well satisfied with what it saw and with the manner in which the directors are endeavouring to meet the demands on their restricted resources. In regard to operational research, the report comments on the value of such work in showing where laboratory research can be most profitably directed, and in the experience which it gives the man of science of working with all kinds of people in an industry. The pioneer work of the Cotton Research Association and the Boot and Shoe Research Association in this field is well known, and the Wool Industries Research Association has now made a close study of faults and irregularities in wool cloth, showing in which of the various stages from preparation to finishing they originate. Since the industry, until recently, employed about one mender for every two weavers, this investigation bears on the use of man-power, as well as on quality. An analysis has now been made of the time required for mending each type of fault and the frequency of its occurrence, thus enabling priority in planning research to be given to the investigation of those faults which are economically the most important, and the industry has shown great eagerness to apply the results of these studies in the mills.

An operational research team set up by the Joint Iron Council and the Cast Iron Research Association has visited more than two hundred foundries during the past two years, and the information gained is leading to the wider adoption of sound and economical practices throughout the industry. A statistical survey of children's feet carried out by the Boot and Shoe Research Association has led to the development of a new series of lasts for children's shoes, which, besides greatly increasing the ability of the industry to make children's shoes fit accurately and comfortably, is of importance for the export market. The Iron and Steel Research Association is making a survey to assess the optimum size of ships that can be handled at the principal ports from which iron ore is dispatched to Britain, and is also studying unloading methods to discover the reasons for the rapid discharge of ships at certain foreign ports and the applicability in Britain of the techniques employed.

In regard to the Cremer report, the Advisory Council agrees that the national interest demands a central organization working in collaboration with manufacturers so as to ensure correlation between basic research and actual operation, but the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association have already arranged to make a more detailed study of information that is available in industrial research establishments and of the resources of these establishments for carrying out further investigations. The survey is expected to take a further six to twelve months and to lead to the establishment of a properly staffed documentation unit. In view of the emphasis laid by the Cremer Committee on improved documentation, arrangements have been made by the Department of Scientific and Industrial Research to prepare bibliographies of selected topics; one on drying has been completed, and another, on crushing and grinding, has been initiated in co-operation with the Institution of Chemical Engineers.

A feature of the summary of work is the increased proportion of space given to the work of the research associations. This is in accordance with the trends of recent reports; it now occupies some 115 pages, as against 72 pages for the work of the research establishments of the Department. The work of the Chemical Research Laboratory and of the National Physical Laboratory has recently been reviewed in these columns, and, from the accounts of the work of the other establishments and the research associations, only a selection can be here made to illustrate the range and extent of the contribution which they make to the national welfare and economy. That of the Joint Fire Research Organization, for example, is preventive rather than of direct value in relation to increased productivity, and is planned mainly in relation to the needs of the various government departments which have responsibilities in connexion with fire protection, and to assist the Fire Offices' Committee and local authorities in framing their requirements. Annual losses from fires usually amount to about £24 millions, approximately half of which is from large fires involving more than £10,000 damage each, and against such figures the significance of the work on smouldering, on the study, with the use of models, of the growth of fire, on the use of water and foam in fire extinction and on dust explosions can be appreciated. Analysis of fire statistics indicates that, while the rate of incidence of fire in television receivers continued to decrease, the hazard is still three times as much as that with radio sets.

Under the Food Investigation Organization, in view of the importance of the problems of storage of home-produced beef, work is being concentrated on improving the quality of frozen meat through the controllable factors prior to slaughter and during storage. Two members of the staff of the Low Temperature Research Station, Cambridge, are working during 1952–53 in the Abattoir Laboratories at Brisbane of the Australian Commonwealth Scientific and Industrial Research Organization and will apply to beef animals on a commercial scale the techniques which have shown promise on the laboratory scale at Cambridge. Preliminary experimental shipments indicate that the better the initial quality of the meat, the less the damage suffered as a result of freezing. Surveys have continued of the wastage and deterioration which occur during the distribution of lettuce, plums, strawberries and Cornish broccoli to the home market, and also experiments on the best storage conditions for certain new varieties of apples

and pears. Work on the production of heat by potatoes stored in bulk has permitted general recommendations regarding the height of stacking and the need for ventilation, and progress has been made in identifying some of the many compounds shown by chromatographic methods to be present in apples. Basic investigations have related to the recovery of ascorbic acid from aqueous extracts of lucerne, and a study of the mechanism of action of phenolases on the naturally occurring phenols present in many plant and animal substances has shown that ascorbic acid is a useful inhibitor of enzymatic browning. The demonstration that *iso*citric and malic acids can be oxidized by enzymes isolated from peas by successive transference of hydrogen from *iso*citric and malic acids through coenzyme II to glutathione, thence to ascorbic acid and finally to oxygen, allocates possible functions to the important plant constituents—ascorbic acid and glutathione. Other investigations on the respiration of plant organs promise to illuminate the balance between carbohydrate and acid constituents which accompanies the ripening of fruits, and may lead to control or prediction of the losses of ascorbic acid during storage of plant organs; they have indicated that sterilizing foods with intense beams of high-velocity electrons is a promising process.

Some basic research has been maintained in all sections of the Forest Products Research Laboratory, but much time has been given to the testing of Colonial and other imported timbers, in order to keep pace with the increasing demand for information on their properties and uses. Measurements on adsorption and desorption within the hysteresis loop have been concluded and confirm earlier findings, and work is now in progress on the effect of temperature on the hysteresis loop. A new system of loading has been developed for testing stresses and similar structural units, and research on the physiology of fungi has included the study of the metabolic products of wood-inhabiting fungi. Much time has been devoted to the development of a new technique for observing the collapse of wood during pressure treatment which will facilitate the accurate determination of the relation between temperature and pressure, while work on the treatment of timber in stick, for the prevention of attack by *Lyctus* powder-post beetles, has aimed at finding improved methods of applying DDT and benzene hexachloride to stacks of timber. Fuel research has included investigations on the nature of the processes of maturing of coal, which are believed to change when the coal acquires a minimum density, and on the mode of occurrence of certain minor constituents in coal. The development of a pilot plant for the generation of water-gas from small-sized non-coking coals in a fluidized bed at about 900° C. is proceeding, and in work on the Fischer–Tropsch process it has been found that the activity of an iron catalyst prepared from magnetic iron oxide and alkali is greatly increased by reduction with hydrogen at 300° C. instead of 450° C. and by removing surface alkali by leaching with water. Investigations on the formation and prevention of external deposits on boiler heating surfaces, on the removal of sulphur compounds from flue gas and on the development of combustion chambers to enable solid fuels to be used in industrial gas-turbines has continued, while many new designs of domestic appliance have been tested and much attention given to atmospheric pollution and its prevention.

The development of the new Hydraulics Research Station continued, and considerable progress is reported in building a second wave-basin in the open in which it will be possible to reproduce tidal currents and the rise and fall of the tide at the same time as waves. Tidal studies have concentrated attention on the problem of siltation in the tidal basin at Tilbury, while a report on the approach channel to Heysham harbour has been submitted and an investigation is being carried out on behalf of Lyttleton Harbour Board, New Zealand, into designs for new extensions to the existing harbour. In the field of coast protection a team of five men, led by an experienced hydrographic surveyor, is making a survey on the south coast of England with the object of recording data for comparison with future surveys, so that an accurate estimate can be made of the gain or loss of beach material; and the team will also attempt to find explanations of how these changes occur.

In the Division of Mechanical Engineering, construction of the Hydraulic Machinery Laboratory, though not of the Heat Transfer and Creep Laboratories, has begun, but most of the work on the properties of materials at high temperatures and the work on the metrology of machine tools and screw threads has to be carried out at the National Physical Laboratory. Fundamental work on grease lubrication has recently begun, and a tentative theory of bearing has been developed to take account of the rheological properties of grease. Experiments on fretting corrosion have confirmed the resistance of phosphated steel surfaces: on surfaces so treated it could be virtually eliminated by suitable lubrication. The performance of precision ball-bearings is being studied with special reference to the dimensional accuracy and finish of the ball and track surfaces, and equipment for investigating high-speed gears has been designed and built by a firm of gear manufacturers. The relation between stress and plastic strain in a polycrystalline aggregate has been used to provide a physical basis for the use of the principle of maximum work in macroscopic theory, tests are being made to establish basic principles governing the plastic deformation of metals in press- and drop-forging, and a micro-technique has been developed for measuring tool-wear so that the machining of large quantities of metal is avoided.

The Pest Infestation Laboratory, which works in close collaboration with the Infestation Control Division of the Ministry of Agriculture and Fisheries and with the corresponding division in the Department of Agriculture for Scotland, is becoming increasingly concerned with Colonial problems relating to the storage of foodstuffs, especially of cereals, where the most immediate needs are for the dissemination of existing knowledge and the assessment of problems on which further research is required. Respiration measurements on wheat grain at different humidities at 25° C., in the presence and absence of micro-organisms, indicate a sharp increase in the rate of respiration of normal grain as the moisture content rises above 16 per cent, accompanied by the development of visible external mould, especially at moisture contents of 18 per cent or more. Subepidermal mycelium appears to have no effect on the respiration of damp grain. The protection against infestation afforded by impregnating jute sacking with pyrethrins or piperonyl butoxide, or a mixture of the two, has been investigated, and all treatments with pyrethrin or the mixtures greatly reduced the likelihood of infestation. Tests have also been made on the relative efficiency of vacuum fumigation techniques and straightforward fumi-

gation at atmospheric pressure. Among the problems investigated at the Road Research Laboratory are the effect of striped pedestrian crossings on road casualties, the braking performance of commercial vehicles, the rear lighting of vehicles in relation to accidents, the behaviour of soils in relation to road construction, the possibilities of prestressing concrete for roads, and the improvement of road tar. Further aspects of the treatment of sewage by alternating double filtration are being studied by the Water Pollution Research Organization, as well as the relative importance of factors affecting the toxicity of poisons to fish, while an increasing proportion of the resources of the Laboratory is being devoted to the study of conditions in the Thames Estuary.

New terms of grant were offered to nine research associations for the next five-year period. The British Boot, Shoe and Allied Trades Research Association receives a block grant of £8,000 a year, conditional on £15,000 from the industry, and an additional £100 for each £100 from industry up to a maximum of £10,000. Reference has already been made to the Association's work on children's shoes, but its day-to-day work on shoe-making materials and components is reflected in all categories of footwear. For the British Cotton Industry Research Association, a block grant of £50,000 a year was made, conditional on £220,000 from the industry, and an additional £100 for each £100 from industry up to a maximum of £40,000 for the period April 1, 1954–March 31, 1957. New developments in the textile industry during the year include the registration of Shirley Developments, Ltd., to take over under formal agreements the many commercialized results already in existence. By this means it is hoped to secure that the practical results of research are more quickly, effectively and fully adopted by the industry. Work on the newer fibres is expected to increase, but cotton still occupies the major part of the research programme. The Association's work on sizing warps is estimated to offer savings in starch to the industry of about £200,000 on £1 million, and the radioactive static eliminator, which has been on trial for two years, is now commercially available.

The new block grant for the British Hat and Allied Feltmakers' Research Association for 1952–54 will be £7,000 a year, conditional on £10,000 from the industry, with up to £5,000 on the £100 for £100 basis. The Association reports advances in the knowledge of mercuric carrotting of rabbit fur, which are leading to a better understanding of the process, and an investigation has been started on the effect of different types of dyeing machine on the quality of felt produced. For the two years 1952–53, the British Food Manufacturing Industries Research Association will receive a block grant of £9,000 a year, conditional on £20,000 from industry, with up to a further £6,000 on the customary basis. Besides studies of analytical methods, the keeping qualities of different types of margarine, and the incidence of mould infection, particularly on strawberries and blackberries, the Association is investigating the graining and rheological behaviour of chocolate, which are important in controlling the physical character of the chocolate and in preventing 'bloom'. For the British Non-Ferrous Metals Research Association the block grant for 1954–56 will be £28,000 a year, conditional on £65,000 from industry, with up to a further £15,000 on the usual basis; more than thirty investigations are at present in hand. A novel method of recovering zinc from galvanizer ash has been developed, the general adoption of which would save the galvanizing industry sums covering its entire subscription to the Association for many years. The Association has also developed an anodic test for a naturally occurring inhibitor of the cold-water pitting of copper pipes, which enables the corrosiveness of a water to be assessed in seven days.

A block grant of £10,000 a year has been made to the British Paper and Board Industry Research Association for the period October 1, 1952–September 30, 1957, conditional on £30,000 from the industry, with up to a further £12,000 on the usual basis. Work on effluent problems continued, and as a first step in a long-term study of fibre structure and properties as they affect paper manufacture and, in particular, of the fundamental effects produced by the beating process, a literature survey has been made and new techniques have been developed in preparing fibres for study under the electron microscope. The possibility of incorporating fungicides in the packaging material during manufacture so as to prevent attack of paper and board by bacteria and moulds is being investigated. Besides a block grant of £40,000 a year conditional on £50,000 from the industry, and up to a further £40,000 on the usual basis for the two years 1952–53, the Production Engineering Research Association has been promised £100,000 towards the cost of a new research building at Melton Mowbray, contingent on at least the same amount from the industry. Research in progress has included investigations to enable the accurate calculation of punch loads for a wide range of ferrous and non-ferrous materials, on the performance of experimental aqueous cutting fluids containing various additives and rust inhibitors, and on the effect of tool surface finish on tool life. For the period April 1, 1952–March 31, 1957, the Coil Spring Federation Research Organization will receive a block grant of £5,000 a year, conditional on £6,000 from industry, with up to a further £10,000 on the £100 for £100 basis, and plans have been made for the establishment of a central headquarters in the Midlands; further work on decarburization and its relation to type of steel, spring manufacture and performance has revealed some important features of the manufacture of springs from black rolled bar, and a study on avoiding hydrogen embrittlement has shown that a variety of oxidizing agents, including chromic sulphuric acid, are effective. The Wool Industries Research Association will receive a block grant of £40,000 a year for the period October 1, 1953–September 30, 1956, conditional on £100,000 from industry, with up to a further £30,000 on the usual basis. General recommendations have been made for the use of synthetic detergents in scouring, and work has been started on the effect of chlorination on the dyed strength and shade of nylon, in the presence and absence of wool, while it has been shown that the frictional forces between clean nylon and keratin surfaces are determined by the elastic indentation of the surfaces and the shear strength of the materials.

Other interesting features of the work of the research associations which may be noticed here are the studies on consumer preference carried out by the British Baking Industries Research Association in collaboration with the School of Bakery, Royal Technical College, Glasgow, which have indicated a marked ability to differentiate between shortbreads containing butter and cake margarine, respectively, and between cake products containing margarine with dried egg and butter with fresh eggs, respectively.

There was no evidence that smokers and persons with artificial dentures were appreciably inferior in their ability to taste. The British Electrical and Allied Industries Research Association's preliminary trials of the 100-kW. wind-driven generator in Orkney are being followed by full performance tests prior to permanent commission; preliminary trials of electric weed-killers have given promising results, and work has started on the flash illumination of laying poultry to increase egg production. The British Iron and Steel Research Association's work on graphite electrodes has led to two types of resistivity tests, the adoption of which in some works has offered savings of four to five shillings per ton of steel. The Lace Research Association has developed a new lubricant for lace machines which is as effective as graphite and offers a minor social revolution in the elimination of the saturation of the workers' clothes with graphite which characterized the old conditions. The designs of the Parsons and Marine Engineering Turbine Research and Development Association for turbine machinery in merchant ships have proved so successful overseas that applications are being received for licence agreements from countries outside the United Kingdom, and six licences have been granted. Interest in the use of conophor oil as a drying oil is rapidly developing, and the Nigerian Government, the Colonial Office and the Paint Research Station are co-operating in exploiting the discovery and establishing a conophor-growing industry. The Printing, Packaging and Allied Trades Research Association has patented a new design of book-binding which allows a book to open flat without major strain to the back; 'Patracrat', its light-sensitive material for making photolithographic plates, has been widely adopted, and much interest has been displayed in its journey shock recorder. The British Rayon Research Association has obtained very promising results with methods it has devised using ultrasonics for the removal of oil stains.

These examples should sufficiently demonstrate how varied is the contribution which the Department of Scientific and Industrial Research is making, alike through its own research stations and organizations and through the industrial research associations, to industrial efficiency and productivity and to almost every side of national welfare. The report shows, too, the extent to which contact and co-operation with industry and with other organizations and government bodies enables the Department to keep in touch with practical needs. Manifestly the wisdom with which the work of the Department is conducted in different fields, and the soundness of the selection of its objectives cannot be judged from an annual report of this order. Confidence in that respect is inspired by the three surveys of the work of the Leather, the Cast Iron and the Ceramics Research Associations which have already been made at the request of the Advisory Council, particularly that of the Leather Research Association. As the Advisory Council points out, however, while such surveys are of considerable value in reviewing progress and assessing priorities, they take time to complete and make considerable demands on the time of all concerned. To conduct such surveys every five years, even for the research associations alone, would be too big a task with existing resources, and the Advisory Council's proposal to arrange for such surveys only when special circumstances indicate the desirability seems reasonable, particularly as it also proposes to require a much more detailed review of the work of each research association before the renewal of grants.

REFRACTOMETRY OF LIVING CELLS

By Dr. R. BARER*, K. F. A. ROSS† and S. TKACZYK†

Department of Human Anatomy, Oxford

SURPRISINGLY little attention has been devoted in the past to the determination of the refractive index of living protoplasm. Earlier workers who investigated the subject were apparently content simply to record values without interpreting their meaning, and the methods employed were rather crude or subject to considerable error. Vlès[1] pointed out that the refractive index of a spherical or cylindrical cell could be determined by treating it as a lens and measuring its focal length. This method only gave average values for the whole cell, that is, nucleus, cytoplasm and inclusions. Even less-precise methods were sometimes used. Thus, the frequently quoted figures of von Angerer[2] for the refractive indices of bacteria were estimated by comparing the subjective brightness (under the conventional microscope) of bacteria with that of oil emulsions. Other techniques have been reviewed in the literature[3].

Methods

The method which we have developed[4] originated in a chance observation. During the course of a survey carried out with the phase-contrast microscope on a wide variety of living cells, it was noticed that the cytoplasm of the amœbocytes of earthworm blood appeared bright instead of dark when viewed by positive phase-contrast (and dark when viewed by negative phase-contrast). This was the reverse of the appearance of all other living cells examined in this laboratory, and could only mean that the refractive index of these cells was less than that of the mounting medium. It was then realized that the latter was not physiological saline or serum, as generally employed, but earthworm blood, which contains a considerable amount of dissolved hæmoglobin, so that the refractive index is appreciably raised. When the blood was washed out with saline, the cytoplasm of the same cells became dark, as usual. In order to determine the refractive index of the cytoplasm, it was only necessary to dilute the blood until the cytoplasm virtually disappeared, and then to measure the refractive index of the diluted blood. As it was inconvenient to use blood or hæmoglobin solutions, a search was carried out for other suitable colourless proteins. After several trials, the material now being used as an immersion medium is a plasma albumin preparation which is available as a dried powder. It is soluble in water or dilute saline up to at least 45 per cent w/v, and its salt content and *p*H can be adjusted to suit the particular cells being examined.

This method is, of course, the well-known 'immersion method' of refractometry which has long been used in mineralogy. It has not hitherto been successfully employed in biology because most of the common non-aqueous immersion media damage living cells. Any substance to be used for the refractometry of living cells must fulfil the following requirements: (1) it must be non-toxic and must not affect the structure or function of living cells; (2) it must not penetrate the cell; (3) it must exert a low osmotic pressure, that is, it must be of high

* Johnston, Lawrence, and Moseley Research Fellow of the Royal Society.

† Supported by Medical Research Council Grants.

molecular weight; (4) it must be freely soluble in water so that the refractive index of the solution can equal or exceed that of the part of the cell to be measured. These requirements are met by the albumin preparation actually used. Numerous experiments have shown that motile cells, such as various protozoa, bacteria, spermatozoa and ciliated epithelial cells, remain active and apparently in good condition for at least thirty minutes (and often for several hours) even in highly concentrated solutions. Cell-division and germination of spores have also been observed. The tonicity of the medium has been checked by plotting distribution curves of cell diameter for spherical cells such as spermatocytes. These experiments and full details of the technique will be described elsewhere.

It seems curious that so simple a method could not have been evolved much earlier. On reflexion, however, its success evidently depends on two fairly recent developments. In the first place, moderately pure preparations of suitable proteins have only been available on a large scale within the past few years. True, some early workers attempted to use gelatin as an immersion medium, but as this sets to a jelly in low concentrations, it is of no practical value. The second factor is the development of phase-contrast microscopy by Zernike[5]. This is an extremely sensitive method for observing local variations of refractive index (or strictly, optical path, that is, the product of refractive index and thickness) and thus enables the match between immersion medium and object to be judged with considerable accuracy. Two-beam interference microscopy[6] has also been used in this work, for which it possesses certain advantages over phase-contrast.

Meaning of Refractive Index: Solid and Water Content of Living Cells

The refractive index of parts of living cells can be measured by this method to an accuracy of the order of 0·001–0·005. Even greater accuracy is possible in some cases, but in general the range of individual variation among cells of one type is greater than the experimental error of a single measurement. The bare figures are, however, of very little interest, and it is only when we consider what they mean that the full significance and possibilities of the method become clear. As a first rough approximation we can regard the living cell as an aqueous solution of protein. If we immerse such a solution in a medium containing the same protein, the refractive index difference between the cell and the medium will vanish when the concentration of protein in the external medium is equal to that inside the cell. Thus, if we were able to use the cell protoplasm as the immersion medium, we could determine its concentration inside the cell. Can we do the same by using a different protein? It is a remarkable fact that equal concentrations of aqueous solutions of different proteins all have approximately the same refractive index. The refractive index varies almost linearly with concentration, and the increase per 1 per cent increase in concentration is known as the specific refractive increment, α. The values of α for nearly all proteins so far studied do not differ by more than about $\pm$ 5 per cent from a mean figure of 0·0018. The extreme cases are the lipoproteins, and pigmented proteins such as hæmoglobin, but even here the variation from the mean is only slight. (The figures in the accompanying table were kindly provided by Dr. G. S. Adair.) Thus, if the cell were composed of protein alone, we could determine its concentration by using almost any protein as the immersion medium. Of course, there are other substances present besides proteins. These might be expected to introduce large errors; but, in fact, the refractive increments of nearly all organic substances in solution (and certainly of those likely to be present in living cells) are very nearly the same. Anomalies may occur with pigments (in the region of absorption bands), and with substances containing conjugated double bonds. Materials of special biological interest are the carbohydrates, lipoids and nucleic acid compounds. The first two usually have low values of α, in the region of 0·0014–0·0015. For nucleic acids, α has been variously given as 0·0016[7] and 0·0020[8]. For solutions of tobacco mosaic virus the value is 0·0017[9], that is, about the same as for much simpler proteins. Hence the error in assuming an average value for α for substances present in appreciable amounts in living cells is small, and only in exceptional cases, as perhaps in cells heavily loaded with pigments, glycogen or lipoids, is any considerable error likely to occur. Thus, in brief, the concentration of protein in the external medium, which makes a certain part of a cell vanish, is also the concentration of total solids in that part of the cell. In many cases the proportion of protein is so great relative to other substances that little error is introduced by regarding this figure as a measure of protein concentration. Clearly, if the total solid concentration is x per cent, then the concentration of water is $(100 - x)$ per cent. A simple observation under the microscope thus gives us accurate information about two very important quantities, the estimation of which has always been a matter of difficulty. Measurements of the water content of living cells involving wet and dry weight determinations lack precision because one can never be sure of removing all extraneous surface water. Indeed, any attempt to dry thoroughly the surface of cells or tissues would almost certainly result in changes of cell permeability, perhaps with further loss of water from inside the cell. The great advantage of the new method is that it can be carried out on the living, and as far as can be judged, undamaged cell, and the results apply to individual cells or parts of cells, instead of being average figures based on large numbers of possibly different cells. In other words, the range of variation of water and solid concentration can be estimated in a given type of cell under different physiological conditions.

Protein	
Total serum (human)	0·00179
Euglobulin	0·00183
Pseudoglobulin	0·00181
Total albumin	0·00181
Recrystallized albumin	0·00181
Lipoprotein	0·00170–0·00171
Hæmocyanin *Helix*	0·00179
Octopus	0·00184
Carcinus	0·00187
Egg albumin	0·001813
Sheep CO hæmoglobin	0·001945
Globin (ox)	0·00178
CO hæmoglobin (ox)	0·00193–0·00195

Specific refractive increments (α) for various proteins (figures provided by Dr. G. S. Adair)

Applications and Results

It is only possible in the present article to mention briefly a few of the different types of problem which have so far been studied by the technique and to indicate the trend of work now in progress.

(1) *General cytology and biology.* In general, the refractive index of the cytoplasm of most types of living animal cell has been found to lie between

1·350 and 1·367, corresponding to between 10–20 per cent concentration of solids. The degree of variation may be quite small in any given species. For example, the cytoplasm of snail spermatocytes and that of snail amœbocytes each has a refractive index corresponding to about 14 per cent of solids, even though the former are compact spherical cells, whereas the latter are very flat and irregular with extremely thin pseudopodial processes. As is to be expected, there is usually some degree of variation between individual cells of the same type from the same animal. As a rule, however, the extreme values rarely differ by more than ± 10 per cent from the mean value, and often the degree of scatter is very much less. Insufficient work has been done to make any statement about the possible correlation between the age or developmental state of an individual and the solid content of its cells; but such an investigation may provide useful clues to the mechanism of ageing. Even in normal human oral epithelial cells there appears to be a progressive decrease in the water content from the inner layers outwards, probably connected with the degree of cornification. The outermost layers may contain more than 30 per cent of solids, the innermost only about 11 per cent. It would be surprising if changes in the distribution of tissue water did not occur with advancing age.

The study of motile organisms is of particular interest both because of the evidence it provides for the absence of serious damage produced by the immersion technique, and because of the light it may throw on the mechanism of locomotion. Many species of protozoa have been observed, and special attention has been paid to some types of amœbæ. These organisms retain their normal motility for at least thirty minutes, even in high concentrations of protein, in which they appear with strongly reversed contrast. In general, the clear ectoplasmic layer of a resting region contains about 8–10 per cent of solids. In active movement, however, the tip of a pseudopodium may contain less than 2½ per cent of solids. This represents a considerable redistribution of water, such as has been postulated in some theories of amœboid movement. One forms an impression that water is squeezed forward into the pseudopodium from the less active 'hind regions' of the organism and that a sudden liquefaction accompanied by streaming of granules takes place.

The human spermatozoon often contains a collar of cytoplasm just behind the head. This contains about 14 per cent solids, as in the cytoplasm of many other cells. The heads, however, are very much denser and contain about 45 per cent of solids. It is difficult to obtain precise values for the tails; but they appear to contain approximately 50 per cent solids. The flagella and cilia of other types of cells are generally also very dense and their solid content cannot always be estimated by this method. In *Euglena*, however, the solid content of the flagella is only about 20 per cent, a value not very much higher than that for the cytoplasm itself.

It seems to be a general rule that many types of cellular activity are accompanied by an increase in water content. Thus in spermatogenesis the appearance of chromosomes may be heralded by a reversal of cytoplasmic contrast. The metaphase chromosomes, in particular, are surrounded by a bright zone of low solid content.

(2) *Microbiology.* Some of the most useful applications of microrefractometry may well occur in the study of bacteria, fungi and yeasts. Many of these organisms show considerable tolerance to *p*H and tonicity, so that the preparation of the immersion medium is greatly simplified. Fully grown bacterial cultures show surprisingly little variation in the individual cells and rather precise end-points are often obtained. In general, there is little difference in the solid content of the same species grown on solid or in liquid medium, provided that the medium contains all the necessary growth factors. Thus, *Sarcina lutea* gave the same value, 35 per cent, in each medium. *Proteus vulgaris* gave values of 28·5 per cent in liquid and 29 per cent on solid media. On the other hand, *Streptococcus hæmolyticus* had a higher solid content (43 per cent) in liquid medium than on solid (34 per cent). Most bacteria so far examined have a rather higher solid content (of the order of 25–40 per cent) than have tissue cells or protozoa. The values for a given strain vary very little, once the culture is fully grown, and the reproducibility of the results, even after many months, is quite astonishing. A study of the variations of solid concentration and mass of bacteria at different stages of the growth cycle and in response to diverse metabolic conditions, including the action of antibiotics, is being undertaken. There is every indication that this technique may be a useful and novel aid in the investigation of bacterial metabolism.

Work on fungi has suggested a variety of interesting problems. The solid content of fungal mycelia varies along their length, and only measurements of the young, actively growing tips are used as a basis of comparison. Nearly twenty species of *Penicillium* have been measured, and the solid content of the active regions is remarkably constant, the extreme values being 24–28 per cent. In *Rhizopus* and *Absidia*, two zygomycetes, however, the value is only about 15 per cent. Such differences may perhaps have some taxonomic bearing.

The behaviour of fungal spores is particularly striking. When a group of spores is examined in certain concentrations of protein some appear bright while others remain dark, in positive phase-contrast. Such spores were actually grown on the slide in the immersion medium. The bright spores invariably germinated and a bright mycelium grew out. The complete growth-cycle to the formation of new spores could be observed. The dark spores remained dormant, or if they germinated, always passed through a stage of reversal of contrast. Here again it appears that cellular activity is accompanied by an increased water content. So far as is known, this is the first time that it has been possible to distinguish spores which are about to become active from dormant ones. Another observation may throw some light on the sexual differentiation of fungi. In *Absidia glauca* the two progametangia which come into contact from different hyphæ show a distinct difference in refractive index. Thus, in 7·5 per cent protein one appears dark and the other bright. Again, this is perhaps the first indication of a structural or chemical difference which could not be revealed by classical methods.

The economic importance of yeasts makes their study particularly desirable. Both brewer's and baker's yeasts have been found to have an exceptionally high solid content (40 per cent) in the cytoplasm of resting cells. The vacuoles give very low values, and the water content of the cytoplasm rises sharply during active budding. As will be indicated below (section 5), the immersion method greatly assists the cytological study of yeast cells by phase-contrast microscopy.

(3) *Studies on cell permeability and death.* An investigation has been carried out in this laboratory into the action of fixatives on living cells[10]. For this reason an attempt was made to study the changes in refractive index produced by different fixatives. The immersion method failed completely, however, and it was never possible to make a fixed cell appear with reversed contrast. The reason for this is presumably that the dead cell becomes permeable to external protein, so that the external concentration never exceeds the internal one. This suggests a new and simple test for cell death or increased permeability, and there is much evidence to support this hypothesis. It may prove possible to detect earlier stages of damage by using solutions of substances of lower molecular weight, and experiments of this type are now in progress. Among the substances we have tried are preparations of peptone and of polyvinyl-pyrrolidone. These are apparently toxic in high concentrations (exceeding about 15 per cent), but amœbæ, for example, can tolerate them for reasonable periods in concentrations of about 12 per cent, and the values for refractive index obtained with protein have been confirmed with both substances. Although most bacteria and fungi so far studied do not show reversal of contrast in concentrated peptone or polyvinyl-pyrrolidone, yeast cells can be reversed by dialysed peptone. This behaviour may possibly be related to differences in the nature of the membranes of these micro-organisms. If some cells, for example, snail spermatocytes, are immersed in high concentrations of polyvinyl-pyrrolidone, both nuclei and cytoplasm may be reversed at first. In a few minutes, however, the cytoplasm becomes dark, but the nucleus remains bright. This suggests that the cell membrane becomes permeable to the material, but the nuclear membrane remains impermeable. The advantages of a simple visual method for studying changes in cell permeability are obvious.

(4) *Hæmatology.* The mammalian red cell can be regarded as a membrane containing a concentrated solution of hæmoglobin. The latter is the major constituent of the cell, and accounts for more than 97 per cent of the total solids, including stroma[11]. Thus, refractometry of red cells is essentially a new method of hæmoglobinometry and one, moreover, which determines a very fundamental quantity in clinical hæmatology, namely, the corpuscular hæmoglobin concentration. Again, this quantity can be determined on individual cells and not, as hitherto, as an average figure for millions of cells. The actual range of concentrations in the cells of any individual can be determined, and work has begun on the task of plotting actual distribution curves showing the relative number of cells containing a given hæmoglobin concentration. Such curves are reminiscent of the familiar Price–Jones distribution curves of red-cell diameter, and despite the considerable labour involved, they must be computed and subjected to statistical analysis in order to understand the nature of normal and pathological variations of the red-cell population.

A survey of various types of blood diseases is being carried out with the collaboration of the Department of Clinical Pathology of the Radcliffe Infirmary, Oxford, and full details will be reported elsewhere with Dr. J. B. Howie. It may be mentioned that the picture in iron-deficiency anæmia is a very clear-cut one. The scatter is usually greater than normal, but the highest members of the population rarely reach the concentration of the normal median. Even quite mild cases of iron deficiency with blood hæmoglobin as high as 80 per cent can be rapidly detected by this method. In pernicious anæmia, on the other hand, the range seems to be shifted in the opposite direction with a median slightly higher than normal, and many members of the population contain concentrations considerably higher than normal. Thus, contrary to current opinion, our results suggest that pernicious anæmia is, in fact, an example of a true hyperchromic anæmia with a raised corpuscular hæmoglobin concentration in some cells, and not simply a normal hæmoglobin concentration with larger cells.

Another hæmatological application which may be of practical value is the recognition of 'dead' cells or functionally abnormal red cells. In section (3) above we stressed that reversal of contrast could only be obtained with living cells. With the present technique we have never found any normal cells which were not reversed in 38 per cent protein solution. If a preparation of normal cells is left to stand over-night in this strength of protein, a proportion of the 'bright' cells becomes dark. Similarly, if a suspension of 'bright' cells is damaged, for example, by narcotics or by sub-hæmolytic concentrations of lytic agents, a number of cells, depending on the degree of damage, become dark. Presumably these cells are 'leaky' and allow the protein to penetrate into their interiors. Blood stored in a refrigerator begins to show a gradually increasing proportion of 'leaky' cells after some time, and this proportion is rapidly increased by keeping the blood at room temperature. It is hoped to devise a simple and rapid test for determining whether a given specimen of stored blood from a blood bank is suitable for transfusion.

Many hæmatological problems remain to be investigated. Apart from the determination of normal and abnormal distribution curves, there are questions associated with the change-over from the fœtal type of hæmoglobin to the adult type, the nature of hæmolytic anæmias, the changes which occur during treatment of anæmias, the possible alterations which blood cells undergo in the spleen, the effect of various anticoagulants, and the influence of different substances on the survival of stored blood.

(5) *Contrast variation in phase-contrast microscopy.* In order to obtain the maximum information from the phase-contrast method, it is essential to vary the refractive index of the mounting medium[12]. This has not hitherto been possible in the case of living cells, and some of these have been regarded as unsuitable for phase-contrast work. Thus, many spherical cells are very refractile and are surrounded by intense and disturbing haloes when examined in saline or plasma media, so that little or no internal structure can be made out. Such haloes can be greatly reduced by immersion in suitable protein solutions, and cytological details can then be readily studied. The method is particularly useful with refractile structures such as yeasts, spores, and some plant cells. The immersion method can also be used for the measurement of birefringence of living cells as already foreshadowed[13].

(6) *Spectrophotometry of cell suspensions.* Suspensions of cells mounted in saline or nutrient media are very cloudy and scatter light. If, however, the refractive index of the cells is determined and they are then suspended in a medium of about the same refractive index, light scattering is greatly reduced and the suspension becomes virtually transparent. Concentrated suspensions of blood cells, for example, can be clarified in this way[14]. It now becomes possible

to carry out spectrophotometry on such material much more accurately and with much more concentrated suspensions than hitherto, and the state of pigments, enzymes, etc., in living animal and plant cells and micro-organisms can be investigated. Results obtained by this method will be reported in detail by one of us (R. B.).

(7) *Combination of refractometry and mass determination.* By means of interference microscopy it is possible to determine the product of refractive index and thickness, and hence the dry mass of a living cell[15,6]. Although refractometry and mass determination are closely related, the information given by the former, that is, the concentration of solids, is generally more fundamental. Thus the knowledge of the actual mass of a structure like an amœbal pseudopodium is of no great interest, because it depends on the size of the pseudopodium, which may be varying rapidly. The local concentration of solids is of much greater value. When the two methods are combined, however, it is possible in principle to obtain a considerable amount of useful information about living cells. If the product of refractive index difference and thickness and the refractive index itself are measured, the thickness can be calculated. The integrated product of thickness and projected cell area then gives the cell volume. Thus, from two optical measurements it is possible to derive (1) the dry mass of part or the whole of a cell, (2) the concentration of solids in different parts of the cell, (3) the cell thickness, (4) the cell volume, (5) the concentration of water in different regions, (6) the total mass of water. Such facts provide a useful basis for much quantitative work on living cells.

This work was made possible by grants for apparatus from the Royal Society and the Rockefeller Foundation. Generous assistance was also provided by the Nuffield Foundation and the Smith, Kline and French Foundation.

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FLAVOUR ASSESSMENT

A SYMPOSIUM on flavour assessment, in which the Food Group of the Society of Chemical Industry, the Biological Methods Group of the Society of Public Analysts and the Biometric Society joined, was held on the afternoon and evening of Wednesday, March 11, at the Wellcome Research Foundation, Euston Road, London. The chairman of the Food Group, Prof. H. D. Kay, took the chair at the afternoon session, and Dr. H. O. J. Collier, of the Society of Public Analysts, and Dr. Katherine Coward, of the Biometric Society, at the after-tea and evening sessions. Some two hundred and thirty people were present.

The first speaker was Dr. E. D. Adrian, who discussed the physiological background of flavour assessment. He pointed out that while the strict physiology of the sense-organs tells us little about the sensations experienced by the individual, which are elaborate constructions of the central nervous system, the physiologist can tell us a good deal about the kind of information which comes in when the end organs are stimulated. The concept presented to consciousness is an edited synthesis of this information; in the case of our appreciation of food and drink, it depends both on the signals coming from the eyes as well as the nose and mouth, and also on the idiosyncratic likes and dislikes acquired during our upbringing and past experience. The physiologist deals with the stage where the environmental change is analysed by the sense organs; he can measure the size, number, grouping and spacing of the brief impulses travelling up the sensory nerve fibres.

The flavour of food is signalled by the taste buds in the tongue and the back of the mouth and the large olfactory organ at the back of the nose. In man, the olfactory organ, which has an area of about 2 sq. cm. on either side, contains several million long, sensory cells, each ending in a hair-like process which projects into the surface layer of mucus and water on the surface of the organ.

With smells, there has always been the difficulty of making any classification or analysis of the qualitative aspects, or of producing a scale of smells. Recent research has left the sensation out of account and recorded the signals which the sense organ sends to the brain. Experiments have been carried out with the rabbit, which has a large olfactory organ, to determine the character of the impulses—changes in electrical potential—passing along the olfactory nerve after a measured stimulus, consisting of a definite quantity of the vapour of a chemical substance of known composition, has been brought to the olfactory surface within a definite and fairly short time. Dr. Adrian showed a number of slides recording these impulses.

With a similar stimulus, the time course of the discharge of impulses is characteristic, and may help the animal to distinguish one smell from another. The esters and substances soluble in water seem to act more rapidly than those only soluble in lipoids. It is possible that there may be different types of reception, perhaps depending on the distance of the cell nucleus in the long sensory cell from the receptor hairs. Thus air which has passed over coffee gives a group of potential spikes on the record of the discharge differing from that given by air which has passed over tea. When pure chemical substances are tried, there seems to be at least four classes of substances of which the discharge patterns can be distinguished. This is most obvious when the stimulus is not too far from the threshold, that is, when only a few conducting units are in action.

How the stimulating molecules of the odoriferous substances excite the end organs is a different problem; but at least we know that the olfactory organ sends the same sort of messages into the brain as the other sense organs, and that judgments of flavour are based on a central editing and synthesis of signals arriving via a fairly large number of afferent channels.

Mr. H. G. Harvey (British Food Manufacturing Industries Research Association) dealt with certain basic considerations in regard to flavour assessment from a somewhat different angle. In the well-fed human, the reaction to flavour is still primitive and largely confined to like or dislike, or preference of one food to another, though many separate sensory messages associated with colour, temperature, texture, taste, odour, obviously enter into any such judgment. Mr. Harvey emphasized the importance of visual appearance, quoting Moir's experiment where table jellies with colours not conforming to the flavours customarily associated with these colours were tasted by a large group of people, most of whom failed to allocate the flavours correctly. When food intended for sale to persons of normal vision is being tested for flavour, the normal association of colour and flavour should be allowed to operate.

Nearly every type of tasting test, Mr. Harvey pointed out, falls into one of two categories: (1) consumer preference and (2) grading, though the way in which particular assessments are made varies widely. A sound statistical planning is necessary, whatever method is used. Mr. Harvey compared, with examples, the 'paired comparison' method and the 'triangular' test, where three samples, of which two are identical, are presented to each assessor. He considered that assessors should, where possible, be given the simplest possible judgment to make. Assessors vary greatly in their discrimination for reasons that are usually obscure, though non-smokers do not seem to show any significant difference in tasting ability from smokers.

Mr. A. S. C. Ehrenberg (Institute of Psychiatry, Maudsley Hospital, London) and Dr. J. M. Shewan (Torry Research Station, Aberdeen), in a paper on the objective approach to sensory tests, illustrated their conclusions from a study of present-day methods of preserving fish in palatable form, using carefully trained taste panels for the assessment of qualities which go a little beyond simple flavour. They endeavour to measure 'eating quality', grading this variable on a ten-point scale, each point of which is given a detailed description. The panel is trained to agree on the association of the descriptive terms and the place on the scale. A major difficulty is to decide whether or not the level of assessment remains reasonably constant over a period of time; quick-frozen fish stored at low temperatures show little change over months of storage and have some value as standards; also, objective chemical measurements (total volatile bases) seem to agree fairly consistently with the position on the 'eating quality' scale given by the organoleptic assessments.

Mr. J. M. Harries (Ministry of Food) also spoke on specialist grading tests and consumer acceptance trials. The consumer acceptance or preference tests, the results of which vary with standards of living, have usually a wide scatter of individual results about an average. When attempting to forecast consumer preference, the scatter is as important as the average. The relation of this variation to the economic concept of elasticity of demand was discussed. In consumer preference tests, the food should be presented in the form in which it is normally used. One method employed is to offer five samples, three (identical) of one kind, two (identical) of another—a method useful in assessing the effect of alternative treatments on the flavour of a given food.

For specialist grading tests, a limited panel of individuals of trained acuity is used; such tests are not concerned primarily with likes and dislikes but are meant to effect a sensory analysis of flavour or other food characteristics, previously formulated in as precise a way as possible, and discussed beforehand by the panel. By such means, it is often possible to place different samples in a consistent order, or on a numerical scale. Mr. Harries reviewed some of the statistical methods of dealing with the test data.

Dr. J. O. Irwin (London School of Hygiene and Tropical Medicine) gave an interesting statement of the biometrician's point of view. There has been in the past a good deal of doubt as to the legitimacy of speaking of the measurement of sensation, and whether the only measurable quantities are the stimuli that evoke the sensation. His view is that the attempt to provide and classify such measurements has, nevertheless, to be made. He referred to the classification proposed by Chambers into (1) nominal, (2) ordinal, (3) interval and (4) ratio scales, and briefly described the use and limitations of each of these scales. The pragmatic approach to ordinal scales, not infrequently used in flavour assessment, is often better than a too pedantic use of a precise form of metric—an example was given of this from results on bacterial plate counts of milk. The biometric assessment of the properties of food, such as odour or flavour, is a type of assay not too dissimilar from, say, the biological assay of the amount of insulin in a given preparation.

Dr. Irwin directed attention to a valuable publication by the U.S. Department of Agriculture, namely, Bulletin No. 34 of the Bureau of Human Nutrition and Home Economics, 1950, in which a thorough examination of many aspects of the 'specialist grading' type of test is given. He ended his talk by scrutinizing from the biometric point of view some of the findings mentioned by the previous speakers.

A short discussion followed the conclusion of each of the five papers presented.

OBITUARY

Dr. Marc Daniels

Dr. Marc Daniels, a member of the Tuberculosis Research Unit of the Medical Research Council, died in London on March 3 at the age of forty-six. Educated in Manchester and Paris, he took his British medical qualification in 1937 and, a few years later, entered the public health field. After two years in Lincolnshire, however, he gained a scholarship at the Royal College of Physicians, a committee of which was directing a survey on the epidemiology and prevention of tuberculosis in young adults, under the Prophit Trust. From this point Daniels concentrated upon tuberculosis, and, after outstanding work in this survey during 1942–45, and in the preparation of its important report, which among other beneficial effects led to the official recognition of tuberculosis in nurses, laboratory workers and certain other categories as an industrial disease, he joined UNRRA as a consultant in post-war Europe. Some of his observations in this sphere were recorded in his Milroy Lectures to the Royal College of Physicians in 1949.

In 1946 Daniels joined the staff of the Medical Research Council, and thereafter was responsible for the practical co-ordination of two important lines of

inquiry undertaken by the Tuberculosis Research Unit under the direction of special committees of the Council. One of these was the controlled trials of BCG and vole bacillus vaccines in the prevention of tuberculosis in school-leavers, now being conducted in Birmingham, Manchester and the Home Counties; the other was the nation-wide trials of the newer chemotherapeutic agents in human tuberculosis (streptomycin, *p*-aminosalicylic acid and isoniazid, the latter being still under test). Although Daniels's most abiding interest lay in epidemiology, his reputation was most enhanced by these—the first strictly controlled—chemotherapeutic trials in tuberculosis; the reports, prepared by him for the committee, received highly favourable comments in many countries, as much for their methods as for their content. Indeed, one of his main scientific contributions was the successful application of statistical methods to group studies in clinical tuberculosis. With the services of Prof. Bradford Hill as statistical designer, and of Daniels as organizer, these trials constituted an advance in the evaluation of new drugs in acute and chronic disease. While occupied with this work, Daniels served on many missions concerned with tuberculosis, for the Foreign Office, the British Council, and the World Health Organization; he was a member of the Streptomycin Subcommittee of W.H.O.'s Expert Tuberculosis Committee.

Daniels brought enthusiasm, precision and modesty to all his work, and he developed many friendships at home and abroad. Having a world outlook on health problems, he was very conscious of the moral and social responsibilities of medical men and scientists in a world needing peaceful development, but subjected to increasing strains and the threat of destructive uses of medical and scientific skill; and he was interested in the Medical Association for the Prevention of War from its formation. He had for many years been a member of the Association of Scientific Workers. He had many other interests, showing discriminating appreciation of art and drama, in both of which he took personal part. Daniels had two daughters by his first marriage, to Anne Burgess. In 1949 he married Kay Graw.

P. D'Arcy Hart

NEWS and VIEWS

Geography at Oxford: Prof. K. Mason

Prof. K. Mason retires from the chair of geography in the University of Oxford at the end of this academic year, after twenty-one years service. He went to Oxford from the Survey of India, at a time when the last of many proposals for an Honour School in Geography was receiving favourable consideration from the University, and thus became heir to the Oxford tradition in geography. He wisely accepted the proposals without serious change and concentrated his efforts on making the new School work smoothly, on collecting a well-qualified staff, and, most successfully, on securing a building which could adequately house the growing number of students reading geography. The splendid lecture theatre, in the design of which he took an active part, is a fitting memorial to this side of his activities. Not least of his services was to induce the Drapers Company to provide three travelling scholarships. Under his administration the numbers have grown continuously from a mere handful in 1932 to about 180 in the present year. He leaves the Honour School of Geography at Oxford firmly established and well fitted for further expansion.

Mr. E. W. Gilbert

Mr. E. W. Gilbert, who succeeds Prof. Mason, is the first Oxford man since the days of Sir Halford Mackinder to direct the Oxford School of Geography. Like Mackinder, he began by taking the Honour School of Modern History—in 1922. He then gained all the distinctions possible at Oxford before the days of an Honour School of Geography, including the degree of B.Litt., for a thesis on the exploration of Western America, afterwards published by the Cambridge University Press (1933). Mr. Gilbert's first teaching post was at Bedford College, London. He next became joint head of the newly established Honour School of Geography in the University of Reading. He returned to Oxford in 1936 as Rockefeller research lecturer in human geography, and seven years later became reader in human geography. Most of his very large number of contributions to geography deal with the human and regional aspects of the subject, and this fact alone is some guarantee that the traditions of Oxford geography will be maintained. Moreover, Mr. Gilbert begins his career as professor with a full knowledge and experience of the Oxford School of Geography. Oxford is fortunate in retaining the services of one of her most devoted sons; the School of Geography has now an experienced and very competent staff; and Mr. Gilbert is fully qualified to maintain the high standards set by his predecessors.

Meldola Medal, 1952

The Meldola Medal is the gift of the Society of Maccabæans and is awarded each year to the chemist who, being a British subject and less than thirty years of age on December 31 in that year, is considered to have shown the greatest promise as indicated by his or her published work. On the recommendation of the Council of the Royal Institute of Chemistry, two candidates have been adjudged equal, and therefore two Medals have been awarded for 1952 to T. L. Cottrell and Dr. B. C. L. Weedon, respectively.

Mr. T. L. Cottrell

Mr. Cottrell graduated in 1943 from the University of Edinburgh and joined the Research Department of the Nobel (then Explosives) Division of Imperial Chemical Industries, Ltd. There he worked in the Organic Research Section until 1946, when he was sent to study in the Physical Chemistry Laboratory in Oxford and investigated the thermo-chemistry of the ionization of some organic acids and also some theoretical problems connected with molecular structure. On his return in 1948 to the Nobel Division, where he is now in charge of the Physical Chemistry Research Section, Mr. Cottrell became interested in the properties of gases at high temperatures and pressures, and in aspects of chemical kinetics. Using a simple quantum mechanical model, he investigated the effect of density on molecular energy and, in

collaboration with Dr. S. Paterson, used the results to derive an equation of state which could be applied in the calculation of the velocity of detonation of condensed explosives. In the course of this work an investigation was made of the conditions under which the virial theorem holds in such calculations. In chemical kinetics he has made a study of the pyrolysis of nitrocompounds, distinguishing between bond breaking and unimolecular mechanisms and, in addition, is at present doing theoretical work on rates of energy transfer in gases.

Dr. B. C. L. Weedon

Dr. Weedon was educated at Wandsworth School and at the Imperial College of Science and Technology, London, and, after graduating in 1942, worked at the Imperial College on the reactions of acetylenic alcohols. He later joined Imperial Chemical Industries, Ltd. (Dyestuffs Division), and spent two years in the research laboratories at Blackley. In 1947 he was appointed to his present position as lecturer in organic chemistry at the Imperial College, and, with Sir Ian Heilbron, until the latter relinquished his chair, and then independently, he worked on compounds of the vitamin A type; as a result, several features in the relationship between biological (growth-promoting) activity and molecular structure were elucidated. Dr. Weedon has been working in the carotenoid field and has developed routes to the synthesis of methylbixin and some related compounds. Another of his current interests is in fatty acids, and he is also associated with Prof. R. P. Linstead in developing anodic reactions of preparative value in organic chemistry. Such methods have, for example, been found to provide convenient routes to a wide variety of straight- and branched-chain, saturated and unsaturated, fatty acids. During this research a novel route to some vinyl*cyclo*propanes was encountered.

New Zealand Department of Scientific and Industrial Research

Mr. F. R. Callaghan has recently retired from his post as secretary to the council and permanent head of the New Zealand Department of Scientific and Industrial Research, and has been succeeded by Dr. W. M. Hamilton, assistant secretary in control of the agriculture and biology branches of the Department. Mr. Callaghan is a graduate of Canterbury University College, Christchurch, and after a period of teaching in the South Island he was appointed in 1916 as instructor in agriculture to the Auckland Education Board. In 1926 he was in charge of the New Zealand Government Court at the Wembley Exhibition, London. Then, in 1927, he joined the newly formed Department of Scientific and Industrial Research, and from the first took a major part in the establishment of the Department on sound lines, helping the secretary in the formidable task of establishing, equipping and staffing the many new units of the Department. In 1936 he also became chief executive officer of the Plant Research Bureau, which comprised the Plant Diseases Division, the Grasslands Division, the Crop Research Division, the Entomological Research Station, and the Botany Division, and he was largely responsible for the development of agricultural research in the Department. Mr. Callaghan was officially appointed assistant secretary in 1935, deputy secretary in 1939, and finally secretary and permanent head in 1947 in succession to Dr. E. Marsden. During his service with the Department he has seen it grow from a small beginning to a large organization of great importance to New Zealand science, and the success of this expansion is in no small way due to his efforts. His successor, Dr. Hamilton, was educated at Auckland University College and Massey Agriculture College, gaining the degree of D.Sc. for his survey of the dairy industry. He joined the Department in 1936 and in 1941 deputized for Mr. Callaghan as chief executive officer of the Plant Research Bureau. He was appointed assistant secretary in charge of the agricultural and biological branches in 1948.

Research Expenditure in the United States

Federal expenditure in the United States on scientific research and development during 1952 was 1,839 million dollars, according to the National Science Foundation, and is estimated as 2,189 million dollars for this year and 2,327 million in 1954. Of this expenditure, the Department of Defence accounted for about 72 per cent in 1952, the Atomic Energy Commission for 14 per cent, and the National Advisory Committee for Aeronautics and the Federal Security Agency for 4 per cent each, with a little more than 3 per cent for the Department of Agriculture. The distribution ratios for the 1953–54 estimates are similar. These figures may be compared with those given for industrial research and development in a preliminary report issued by the Research and Development Board, Department of Defense (Washington 25, D.C.). Based on a survey made during the middle of 1952 of about two thousand companies that are estimated to handle 85 per cent of all industrial research and development in the United States, this report indicates that the co-operating companies spent nearly two thousand million dollars on research and development in 1951, half of which was financed by the Federal Government, and 97 per cent of this government programme was sponsored by the Department of Defense and the Atomic Energy Commission. The survey covered some ninety-four thousand scientific workers and engineers and a hundred and forty thousand supporting workers; of all these, more than half were employed in the electrical machinery, aircraft and chemical industries. Nearly 90 per cent of the scientific workers and engineers were working in manufacturing industries, and 55 per cent in the electrical machinery, aircraft and chemical industries; more than a third were employed by less than twenty companies which have research staffs of a thousand or more, and less than 2 per cent were employed by six hundred companies with staffs of less than five professional workers. The electrical machinery, aircraft and chemical industries account for 55 per cent of research expenditure, but the chemical industry, which ranks third in respect of expenditure on research, received only 7 per cent of its expenditure from Federal funds. The report refers to a greatly increased rate of turnover of scientific workers and engineers and to the vulnerability of industry engaged on defence research programmes to demands of military service.

Royal Scottish Forestry Society: Centenary Endowment Fund

In February 1954 there will be an important forestry centenary, for, a hundred years previously, the Royal Scottish Forestry Society, the senior forestry society in the British Commonwealth, was founded. Particularly from the beginning of the

eighteenth century, many Scottish landowners had pioneered in planting, and, in the middle of the nineteenth century, interest had been quickened by the introduction of conifers from the Pacific slope of what was to become the north-west States of the United States and British Columbia. From its foundation, the Society has stimulated and co-ordinated interest and the development of forestry in Scotland; but its influence has been felt far beyond the bounds of that country. It helped to promote the establishment of chairs in forestry in the Universities of Edinburgh and Aberdeen, and it continues to strive to extend education in forestry. The Society has taken a leading part in advocating the need for a national forest policy and a State forestry department, and in the latest post-war period it has helped directly and indirectly to mould government policy in relation to private forestry. Like many societies in these days, its income is proving inadequate for its necessary activities; a Centenary Endowment Fund of £10,000 is therefore being started. Donations should be sent to the Treasurer, Royal Scottish Forestry Society, 7 Albyn Place, Edinburgh, 2.

Nuclear Research in Yugoslavia

The growth and development of nuclear research in Yugoslavia, and of the Institut de Recherches sur la structure de la Matière at Vincha, near Belgrade, is mainly due to the efforts of Prof. P. Savich, the present head of the Chemistry Laboratory. When, late in 1948, the building of the Institute was commenced, Prof. Savich was one of the only two men of science in Yugoslavia who could claim any previous experience of nuclear physics. Since then, however, about a hundred young physicists, chemists, mathematicians and engineers, many of whom have been trained in Yugoslav universities, have been gathered together to form the physics, chemistry, applied mathematics, electronics and biological sections of the Institute. The present director is S. Dedijer, and Dr. R. J. Walen is in charge of the physics section. The Institute possesses a Cockcroft–Walton type of accelerator, giving 1·5 MeV., and preliminary studies for the construction of a nuclear reactor are being undertaken. The progress made and the standard achieved may be judged from the collection of the first sixteen scientific articles published by members of the Institute, which has recently been issued (*Recueil de Travaux de l'Institut*, 1; 1952. Pp. 120; from the Institute, Belgrade). Six of the articles are in English, nine in French and one in German (with English summary). They deal mainly with instruments and techniques useful in nuclear energy research, and include articles on impulse amplifiers, a large-window rectangular β-particle Geiger–Müller counter, the fluorimetric determination of uranium in ores, the determination of feeble concentrations of heavy water, the uses of mass spectrometers, glass-to-metal seals, the structure of electrolytically deposited copper, measurements of β-ray spectra, the retardation of neutrons, and particle track lengths in photographic emulsions.

Presentation of Technical Information

Subsequent to Prof. R. O. Kapp's lectures on "The Presentation of Technical Information", given at University College, London, in 1947, an informal discussion group was formed which, in October 1948, entered on a formal existence under the title, Presentation of Technical Information Discussion Group (Secretary: B. C. Brookes, University College, Gower Street, London, W.C.1). The objects of the Group are to interchange ideas and experience of the art of exposition, and to encourage the development of any methods of presenting technical information which promise to raise the general standard of exposition. A paper read at a meeting of the Group on November 19, 1952, by J. W. Godfrey, deals with the preparation and production of technical instruction manuals and has been issued as Group Paper D.G. No. 1. It discusses the qualifications of a technical writer, the considerations which may lead an organization to set up a technical publications unit and the problems of co-ordination which may arise in such a writing unit. Some notes are also included on difficulties, such as formulæ, in the preparation of typescript for letterpress, and on methods of production, including the production of illustrations.

Health Education in Rumania

In the summer of 1952 Dr. S. Leff, medical officer of health to the County Borough of Willesden, visited Rumania, and he has recorded some of his impressions of health activities in that country (*Health Educ. J.*, 11, No. 1; January 1953). Before the War most Rumanian babies were born in home conditions of great ignorance and poverty; doctors and midwives were almost unknown in rural areas. During recent years the Rumanian Ministry of Health has built more than one thousand maternity hostels throughout the country, each with a doctor and midwife in attendance. These hostels are small; but, within a period of about two years, the number of mothers delivered under aseptic conditions in them rose to almost 100 per cent. The combination of measures for health education and the raising of the standard of the health services has resulted in a large reduction in the maternity mortality-rates and in the halving of the infant mortality-rates within four years. Another example of the results that can be achieved by health education is the Rumanian experience in combating typhus. Up to the end of the War, 72,000 people suffered from typhus annually, largely owing to dirt, lack of washing facilities and illiteracy. In 1952 the number had fallen to a few hundred. This was accomplished as the result of an extensive health education campaign throughout the country. The success of this campaign has been repeated with malaria, where the number of cases has been reduced from 50,000 annually to 5,000.

Embryology of the Orobanchaceæ

Cistanche tubulosa, like other members of the Orobanchaceæ (Personales), is a leafless total parasite, growing on the roots of *Acacia* and other trees. In an investigation of its embryology, B. Tiagi (*Lloydia*, 15, 3, 129; 1952) has found that the embryo sac is not characterized by any unusual features, but after fertilization the embryo remains small and relatively undeveloped. In the small mature seed the embryo is an ovoid structure with tissue differentiation but without differentiation of plumule, cotyledons or radicle. The cellular endosperm forms a rather feeble chalazal haustorium but a very aggressive micropylar haustorium, with intercellular hyphal-like branches which penetrate the integument. These endosperm developments, however, are general in the autotrophic Scrophulariaceæ and are not correlated with the parasitic habit in *Cistanche*.

Nutrition Society Conference on Scurvy

THE Nutrition Society is holding a two-day conference in Edinburgh during May 22–23, in honour of the bicentenary of the publication of James Lind's "Treatise of the Scurvy". After an opening ceremony in the University Upper Library, Surgeon Vice-Admiral Sir Sheldon Dudley will give an address on Lind, and Sir Edward Mellanby will then take the chair at the first session; the chairmen at other sessions will be Vice-Admiral Sir Alexander Ingleby-Mackenzie, Prof. R. C. Garry and Dr. L. J. Harris. Thirteen papers will be read dealing with various aspects of scurvy and vitamin C, of which six will be by authors from the United States and one each from Belgium, France and Holland. Further information can be obtained from Dr. C. P. Stewart, Department of Clinical Chemistry, Clinical Laboratory, Royal Infirmary, Edinburgh.

The Night Sky in May

NEW moon occurs on May 13d. 05h. 06m., U.T., and full moon on May 28d. 17h. 03m. The following conjunctions with the moon take place: May 10d. 19h., Venus 4° S.; May 14d. 11h., Mars 4° S.; May 25d. 09h., Saturn 8° N. Mercury is a morning star, rising at 4h. 15m. on May 1 and at 4h. on May 15, and is in superior conjunction on May 24, after which it becomes an evening star but is too close to the sun for the remainder of the month to be favourably seen. Venus, a morning star, rises at 3h. 30m., 2h. 55m. and 2h. 20m. on May 1, 15 and 31, respectively; its stellar magnitude is about $-4{\cdot}2$ during the month, and the visible portion of the illuminated disk varies from 0·1 to 0·36. Mars sets at about 21h. during the month, which is an hour after the sun at the end of the month and it will then be difficult to observe. Jupiter sets at 20h. 50m. and 20h. 15m. on May 1 and 15, respectively, and is in conjunction with the sun on May 25, after which it becomes a morning star but cannot be observed during the remainder of the month. Saturn rises in the afternoon, and some time after sunset remains visible until the early morning hours; it is easily recognized by its proximity to Spica, and its stellar magnitude averages about 0·6. The η Aquarid meteor shower is active in the early part of May and is visible in the early-morning hours. For many years it has been believed that this shower was associated with the debris of Halley's Comet, but recent work carried out by Prof. A. C. B. Lovell and his team at Jodrell Bank, University of Manchester, has thrown some doubt on this connexion, although further research is necessary before a definite pronouncement can be made. The velocities of these meteors obtained by radar methods at Jodrell Bank are less than would have been expected from the debris of Halley's Comet, but the results are not yet conclusive.

Announcements

IN the Department of Nuclear Physics of the Australian National University, Canberra, Dr. B. D. McDaniel, associate professor of physics in Cornell University, has taken up his duties as a visiting Fulbright Fellow, and Dr. J. H. Carver, formerly of the Cavendish Laboratory, Cambridge, has been appointed a research Fellow in the Department, working with Prof. E. W. Titterton on photo-disintegration problems.

THE Royal Dutch-Shell Group of oil companies is offering a research studentship in geophysics, of value £400 a year and tenable for two to three years at the University of Cambridge, which is open to men of any nationality less than twenty-seven years old. Further information can be obtained from Mr. B. C. Browne, Department of Geodesy and Geophysics, Downing Place, Cambridge. Applications must be completed by July 1.

THE Development Commission is offering a few grants to British honours graduates for training in research problems in marine or freshwater science, which is designed to fit them for employment either in the Fishery Research Services of the Ministry of Agriculture and Fisheries and the Scottish Home Department or in a marine or freshwater biological research institute. The grants are worth £250–£350 a year, with extra university fees paid, and are tenable initially for one year, but renewable up to a maximum of three years. Application forms, to be returned by May 20, can be obtained from the Secretary, Development Commission, 6a Dean's Yard, Westminster, London, S.W.1.

THE annual Cornell University summer laboratory course in techniques and applications of the electron microscope will be given in the Laboratory of Electron Microscopy of the Department of Engineering Physics during June 15–27, under the direction of Dr. Benjamin M. Siegel. The course is designed for research workers, both in academic institutions and in industry, who have recently entered the field of electron microscopy or who are planning to undertake research problems involving applications of the instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, N.Y.

A SPECIAL summer course in the thermodynamics of equilibrium and non-equilibrium states will be given at the Massachusetts Institute of Technology during June 29–July 10. The course, which is designed especially for teachers, research workers and development engineers, will provide an exposition of classical thermodynamics and explore the newer extensions of the subject into the kinetics of processes in which non-equilibrium states play an essential part. Besides the general lectures, a number of special topics will be discussed, including a biography of Count Rumford (the bicentenary of whose birth at Woburn, Mass., has been celebrated this year), the thermodynamics of irreversible processes, the third law of thermodynamics, the thermodynamics of compressible fluids, and critical points and transitions of the second kind and other related subjects. Further information can be obtained from the Director of the Summer Session, Room 3–107, Massachusetts Institute of Technology, Cambridge 39, Mass.

A BIBLIOGRAPHY on cholinesterases and the anti-cholinesterase drugs is being prepared by Dr. K.-B. Augustinsson, of the Biochemical Institute, University of Stockholm (Odengatan 63, Stockholm 6), covering all published (official and unofficial) reports and patents, etc., in this field. In order to facilitate the compilation of this bibliography, Dr. Augustinsson requests that complete sets of relevant reprints be sent to him at the above address. If this is not possible, he would be very grateful for bibliographical details, and also any further information such as possible future publications and the names and addresses of librarians who might be prepared to co-operate in gathering together material.

DEVELOPMENTS IN METHODS OF MICROSCOPY

A WELL-ATTENDED symposium and exhibition, organized by the Royal Microscopical Society (Industrial Section) in collaboration with the Spectroscopy Group of the Institute of Physics, the Optical Group of the Physical Society and the Physical Methods Group of the Society of Public Analysts and Other Analytical Chemists, was opened at King's College, London, on March 20 by Prof. J. T. Randall. Prof. Randall welcomed the co-operation of the four societies concerned, which he said is a recognition that to-day microscopy is not the servant mainly of only one discipline, but of many.

The meeting consisted of three sessions of papers in the anatomy lecture theatre, while an exhibition of apparatus was staged in the Physics Laboratories at King's College. In the first session, Dr. A. E. J. Vickers surveyed the use of the polarizing microscope in organic chemical research. Optical measurements such as refractive index, birefringence, can be made, which characterize and identify materials. He showed a number of microscopes of different design, as well as accessories such as universal stages, for meticulously orienting crystals. Polarization was also the subject of two of the five short papers of the second session. Mr. E. G. Steward showed how X-ray analysis, together with examination of birefringence, can identify components of mixed minerals. He also exhibited a simple hot stage for studying polarizing microscope interference figures of crystals at raised temperatures: 200°–300° C. could easily be obtained with negligible heat loss, cooling arrangements being unnecessary. Dr. R. Barer discussed polarization of the fluorescent light emitted by certain crystals, and suggested this might be used for determining the orientation of molecular planes.

Mr. M. G. L. Curties discussed the testing of microscope objectives with the Baker–Smith interferometer, in which shear is obtained by birefringent elements. He showed interferograms of aberrant objectives and the effect of unsuitable cover glasses and immersion oils. Dr. H. H. Hopkins spoke on the influence of the illuminating aperture on optical images. The partial coherence of the light in the object plane depends on the aperture of the illuminating system. Some results obtained by a generalization of the diffraction theory of image formation were given, including the influence of aberration and condenser aperture on images of periodic structures, of lines of negligible width and of straight edges. Dr. M. H. F. Wilkins described a solid fused-quartz ultra-violet microscope water-immersion objective of N.A. 0·90, constructed with spherical surfaces. The quartz/aluminium reflecting interfaces are internal, so that atmospheric deterioration is prevented. Photomicrographs as examples of the performance of the objective were exhibited: the same field taken in infra-red and in ultra-violet showed the relative quantities and distribution of hæmoglobin and nucleic acid in developing red cells.

Among other exhibits was a double-refracting interference microscope with variable phase, shown by Mr. F. H. Smith. The optically matched condenser and objective pairs with double-refracting components each exert a double-focus effect. The condenser illuminates axially separated planes of the specimen with the same portion of the luminous source, while the objective brings the two separated planes into coincidence in the image plane. The interference of the images is controlled by a double-refracting phase-shifting system. Prof. S. Tolansky exhibited a device for showing the profile of a surface. The shadow of a thin opaque line thrown at an angle on to a flat surface under the microscope appears straight, but if the surface is corrugated the line faithfully contours the corrugations. An infra-red reflecting microscope of N.A. 0·8 and focal length 13·5 mm. was demonstrated by Dr. W. C. Price; it is constructed with large mirrors to give a long working distance and to match the optics of an infra-red spectrometer. The focal length permits the objective to be used at the low magnifications necessary for infra-red work. Dr. P. M. B. Walker showed a densitometer for recording the density in photomicrographs by a double-beam system incorporating a circular density wedge, and he and Dr. H. G. Davies showed a photomultiplier attachment for photometric microscopy. Dr. W. E. Seeds exhibited an ultra-violet monochromator for use with a microscope of low aperture and high dispersion. It is a reflecting system involving two passages of light through a 60° quartz prism: with a line source, large field areas can be illuminated monochromatically.

In Mr. J. R. King's apparatus for examining opaque objects by fluorescence microscopy, ultra-violet radiation suitably filtered from a high-pressure compact source mercury vapour lamp is reflected on to the specimen from above by a Chapman and Aldridge illuminator with aluminized surfaces, as modified in the Beck–Chapman illuminator. A new technique for examining fine particles of such materials as coal, which is only translucent when thin, was demonstrated by Dr. R. G. H. Boddy. The particles are collected by the 'delta' technique, the deposition of the dust on a slide being watched under the microscope to obtain an adequately sized and distributed sample. The particles are then crushed by a specially designed condenser while the process is under observation, the measurements of the particles and the manner and results of crushing affording new information about them. A two-circle goniometer of unconventional design to provide a robust and simple apparatus for measuring crystal angles was exhibited by Mr. W. T. Moore and Mr. L. W. Codd. Dr. R. Barer and Dr. W. Weinstien demonstrated a microscope lamp designed to fulfil the two conflicting requirements for Köhler illumination: for high-power objectives a large aperture has to be filled, but the field of view is small, while for low-power work the field is large and the aperture small. The new lamp uses one fixed lens and two interchangeable lenses to provide combinations suited to objectives and condensers commonly used.

A historical note was struck by Mr. F. C. Grigg, who illustrated, from the Royal Microscopical Society's collections, the development of the microscope slide. Leeuwenhoek made special microscopes for individual objects: the rotating object holder later became popular, with talc windows enclosing a variety of objects. The ivory slide held the field for more than a century, and early glass slides, also with a number of objects, were long and narrow. The first 3 in. × 1 in. glass slides were covered with ornate

paper covers: the present uncovered slide has now been used exclusively for upwards of fifty years.

Finally, among the exhibits was a small electron microscope shown by Mr. R. H. Horne.

The third session, a paper on cinemicrography, was given by Mr. R. McV. Weston. He discussed the apparatus and general technique of filming through the microscope and the difficulties that arise when cinecamera and microscope are harnessed together, mentioning vibration, weight, size of film and apparent changes of speed with magnification. He showed lantern slides of a number of famous pieces of apparatus and finished with a fascinating film he had made, the only one so far to have been taken at 3,000 exposures per sec. through the compound microscope: it showed what happened to the mercury at the constriction in a clinical thermometer immersed in warm water. MARY DEMPSEY

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

OPEN DAYS

DURING the week beginning March 23 the British Non-Ferrous Metals Research Association held open days during which representatives of members and other industrial companies, university staffs and government scientific workers were invited to visit the laboratories at Euston Street, London, N.W.1. A total of more than eight hundred persons went during the week, and, at a press conference held on the first day, some fifty newspapers and periodicals were represented. The equipment of the laboratories was demonstrated, and the Association's present researches with some of those recently concluded were illustrated by exhibits.

The work of the Association covers every aspect of metallurgy, including extraction, melting and casting, working, mechanical and physical testing, corrosion, analysis and metal finishing. Major research projects, of which there are forty-two in hand at the moment, are selected from those problems which are of interest to groups of the Association's members and which can be more satisfactorily handled on a co-operative basis than in an individual works laboratory. Members co-operate with the Association's staff, which exceeds one hundred and fifty in number, by making available through a number of advisory committees knowledge within the industry on the problem in question; in some cases, members carry out in their own laboratories specific items in a research for which they have special facilities and try out some of the Association's investigations on a production scale for the benefit of other members.

The exhibits at the open days naturally referred mainly to the work actually carried out in the laboratories in Euston Street and were too numerous for comprehensive description. The following notes select a few items for special mention.

Pressing of aluminium alloys. One of the difficulties in the production of sheet-metal pressings in the aluminium–magnesium alloys, which are otherwise the most suitable for this purpose, is the appearance of markings in the less severely worked parts of the sheet due to uneven yielding. These are called stretcher/strain markings and are similar in appearance to those occurring in steels. The true nature of these markings has been investigated and the causes of their formation ascertained in the laboratories. From this basic knowledge practical recommendations for their avoidance have been made, and the effectiveness of the measures suggested has been established by works trials carried out with the collaboration of several members. The industry is now in a position to supply aluminium–magnesium alloy sheets which are not liable to these markings.

Improvements in bronze foundry practice. Over many years the Association's work in this field has established the principles governing the avoidance of gas and shrinkage unsoundness, and the present work is largely concerned with the application of this knowledge in industrial production. A special investigation is also being made in the use of insulated feeder-heads which not only improve the feeding of a casting but also greatly reduce both the weight of metal melted for a good casting and the labour involved in fettling.

Titanium. Although some exaggerated statements have been made about titanium, there is no doubt that its remarkable strength and corrosion resistance, coupled with its relatively light weight (intermediate between aluminium and steel), make it an extremely promising material for many engineering applications. The present high cost restricts very much its potential uses, but the prospects for the future are such as to make it important for Great Britain to play its share in the development of titanium alloys. The Association has investigations in this field in hand on behalf of the Ministry of Supply, and is provided with special equipment and experience in the techniques necessary for the handling of this highly reactive element.

Prevention of corrosion. Many of the applications of non-ferrous metals in engineering practice depend on their intrinsically high corrosion resistance, and the urge to develop better materials for particular applications is very pressing. In the field of condenser-tube alloys, the Association is pre-eminent. Aluminium brass, which is now very widely used in marine and land installations, was developed in the Association's laboratories, and the beneficial effect of iron additions in the 70/30 cupro-nickel alloy, which is widely accepted as the best all-round material for marine use, was fully established by the Association's work. This was followed by the development of copper–nickel–iron alloys of low nickel content, which are easily worked by the coppersmith and are resistant to corrosion by moving sea-water.

Similar work has been carried out on materials for the conveyance of fresh waters. For example, the occasional pitting to which copper water-pipes are subject has been traced in part to a film of carbon formed during the annealing operation which, when recognized, can easily be avoided, and in part to the absence from some waters of a naturally occurring corrosion inhibitor. Attempts are at present in hand to isolate and identify this inhibitor.

Metal economy. Researches designed to improve the efficiency of the manufacturing operations or to lengthen the service life in a particular application all promote the economical use of metals, and most of the Association's work comes in this category. Some researches have, however, been specifically aimed at problems in this field, such as the recovery of copper from pickle liquors, reduced consumption of zinc in galvanizing and more effective use of nickel in electroplating.

Metal finishing. One of the main investigations in the relatively newly formed Metal Finishing Laboratory at Euston Street is on the use of nickel in electroplating. Other researches in that field, designed to improve technique, are those on the electroplating of aluminium and on chromium deposition. The plating of aluminium is difficult, due to a tendency of the basis metal to form a film which prevents proper adhesion of the deposit. This is overcome by the initial formation of a thin zinc coating in one of two ways: chemical replacement, or electrodeposition. The conditions necessary to secure the optimum results in both these methods have been worked out, with marked improvement in industrial practice as a result.

Analysis. In the analytical field, the Association is responsible, apart from a vast amount of analysis required in its own investigations, for the development of new methods and apparatus. The exhibits during the open days covered an extremely wide variety of analytical methods, including the determination of gases in metals. In the chemical field great use is made of the polarograph (including derivative polarography) and of the spectrophotometer. In the field of spectrographic analysis, the Association has been responsible for a great deal of work aimed at improving the range and accuracy of the method. A direct-reading spectrograph (Quantometer) has recently been acquired, designed for the examination of copper alloys. The accuracy and field of use of this instrument are being explored in the light of its known success in the aluminium and steel industries.

DEODAR AS PENCIL WOOD

UNTIL recently the so-called East African cedar (*Juniperus procera*) from Kenya has held sway in Britain, the United States and elsewhere as providing the highest class of pencil. Formerly the eastern red cedar of America (*Juniperus virginiana*) was widely used for pencil-making in the United States; but supplies gave out and the Kenya cedar held pride of place for the best-class and highest-priced pencil. Another tree used for this purpose in the United States is the incense cedar (*Libocedrus decurrens*), which grows in California. The use of the beautiful Indian deodar wood (*Cedrus deodara*) for pencil slats is a new idea, due to the research work undertaken at the Research Institute at Dehra Dun, and Indian Forest Bulletin No. 149 (New Series) gives a brief account of this new application*. The deodar has been extensively used in the past for other purposes: after the Sikh Wars in the Punjab (1849), the province was taken over and the British made acquaintance with the deodar, practically the only wood used by the local people, in the building of stations and cantonments; later, in the early 1860's, with the coming of the railways, the wood was in even greater demand for making sleepers.

The habitat of the deodar is the north-west Himalaya at approximately 6,500–8,000 ft. It has a strong timber, of good grain and easy to work, and is free from warpage. The trees are felled on contracts by the mountain people, converted *in situ* as required for logs or sleepers and floated down the mountain rivers to the part of the hills where they are collected in depots and built into rafts for the rest of the journey. The forests and work are mostly under the supervision of the government forest department. From the work done at the Institute, it is claimed that the wood makes first-class pencils. Unfortunately, its colour is light yellow; it is thought the public would be suspicious of the unusual colour, so the deodar slats are stained with a dye to a more popular colour. If the deodar pencil can be put on the market at a paying price, the results should be satisfactory, for the consumption in India to-day is about half a million gross of pencils, of which the deodar will supply the demand for higher quality pencils and save imports.

In supplies of material it is hoped to make use of part of the millions of cubic feet of sawn timber extracted every year as shipur; but perhaps more particularly to exploit the huge amount of off-cuts and small pieces left in the forest after the shipur conversion. The bulletin is silent as to the methods by which this material can be collected on the mountain-side in forests where chain-felling is not practical, and it also gives no indication as to the costs of such collection.

* Indian Forest Bulletin (New Series). No. 149 (Wood Seasoning): Deodar as Pencil Wood. By M. A. Rehman and Jai Kishen. Pp. iv+7. (Delhi: Manager of Publications, 1951.) 5 annas; 6*d*.

EARTHQUAKES DURING 1952

DURING 1952 there were eighty-nine earthquakes each having a magnitude 6 or greater than 6 on the Richter logarithmic scale. The greatest two had magnitudes 8¼ and about 8¼, these being rather less than the greatest the world has known. One of the two occurred on March 4 from an epicentre near the east coast of Hokkaido, Japan. Fissures in the earth were caused, and a section of the cliff sank into the sea. Several bridges were damaged, railway lines were buckled and two trains were derailed. When buildings collapsed, fires were started. There was probably some geological fault displacement in the sea-bed also, as a tsunami with waves up to eight feet high swept the coast and swamped a fishing fleet of twenty boats at Uzumai village. At least 31 people were killed and 169 injured, and there was extensive damage to property.

The other earthquake occurred on November 4 from an epicentre near the east coast of Kamchatka (see *Nature*, **170**, 914; 1952). The epicentre, as calculated from observations at eighty-one observatories by the workers at the International Seismological Association Central Station at Strasbourg, was situated at lat. 52·9° N., long. 160·1° E., and the initial time was 10 hr. 58 min. 23 sec. G.M.T. The macroseismic effects in Kamchatka are not yet known, but the earthquake started a great tsunami which spread across the Pacific Ocean and reached as far as the shores of New Zealand, the Hawaiian Islands and South America.

During the past year five earthquakes were reported with a focal depth equal to, or greater than, 400 km., the one with the greatest focal depth (700 km.) being on February 11 with its epicentre in the Java Sea.

There were a number of earthquakes in or near Europe, and these included the following. On January 3 an earthquake occurred with epicentre near Hasankale in Turkey, Erzurum being affected; the shock caused damage to some 1,570 houses, and at least 94 persons were killed and 262 injured. On February 7 an earthquake at Arette in the Low Pyrenees, and on February 24 another near Worms

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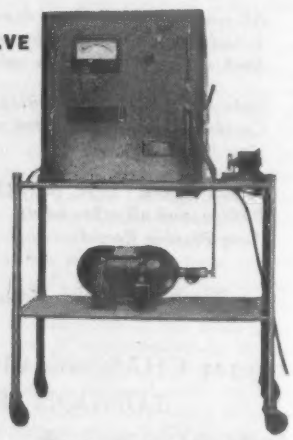

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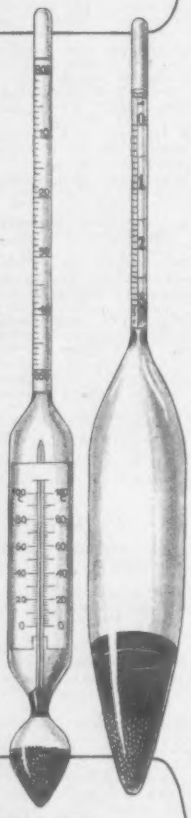

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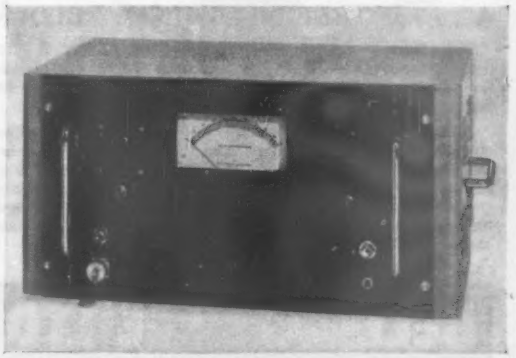

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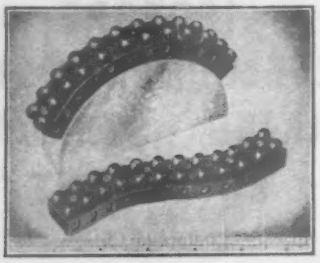

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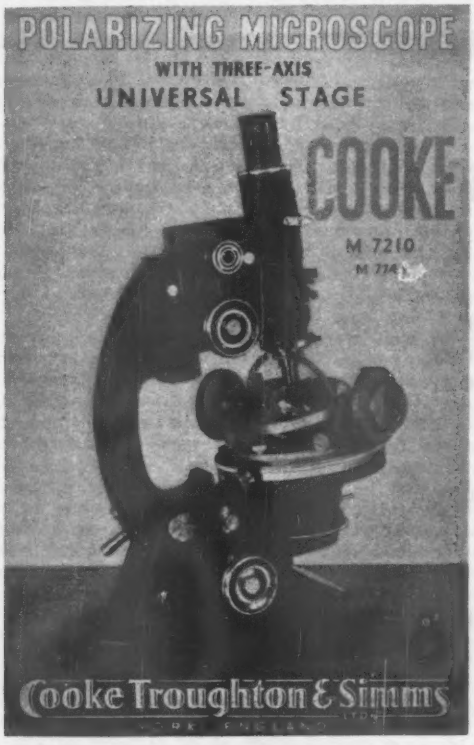

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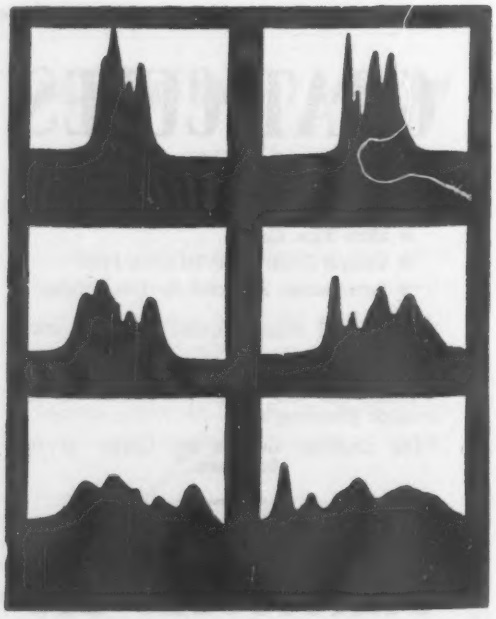

HILGER

and Ludwigshafen in the lower Rhine valley, were both felt with intensity 7 on the Modified Mercalli scale. On February 22 an earthquake took place with epicentre near Winster in Derbyshire. Chimney-stacks collapsed and walls of buildings, chiefly in the main street, collapsed; some slight damage was done in the surrounding district, and it is likely that movement took place along the Crich–Cromford–Bonsall fault. The shock was accompanied by a sound like a double explosion. On March 9 an earthquake was felt with intensity 8 at Etna in Sicily, and on the same day a strong one occurred in north-west Turkey. An earthquake with intensity 7 was felt on May 20 at El Palmar in Spain. Shocks with intensity 8 occurred on June 8 at Pierre Longue (France), on June 13 at Perivola (Peloponnese Islands) and on June 26 at Riberra Quente, Azores. On September 29 an earthquake was felt with intensity 7 at Munchhausen and Soufflenheim in the lower Rhine valley, and on October 8 there was a shock in lower Alsace with the same intensity. Twelve people were killed and a hundred injured on October 22 in an earthquake in the Adana district in Turkey.

Other earthquakes causing property damage and casualties occurred as follows. On July 21 in the Tulare Valley in southern California an earthquake caused extensive damage and several people were killed. The town most seriously affected was Tehachapi, some hundred miles north of Los Angeles. Permanent vertical ground movement at Bear Mountain fault was as much as one metre. On October 14 an earthquake from an epicentre at lat. 8·5° N., long. 83° W., near the south coast of Costa Rica, resulted in casualties and property damage, as did one on October 28 in Haiti (epicentre at lat. 18·5° N., long. 73·5° W.). On November 22 an earthquake caused slight property damage in San Luis Obispo County, California.

Reports have been received from the United States Coast and Geodetic Survey in co-operation with Science Service and the Jesuit Seismological Association, the International Seismological Association at Strasbourg, and from observatories at Aberdeen, Arkansas, Beograd, Cleveland (Ohio), De Bilt (Netherlands), Durham, Fayetteville (U.S.A.), Karlsruhe, Kew, Pasadena, Perth (Western Australia). Stuttgart, Toledo, Wellington and the New Zealand stations (including Fiji), and Zurich and the Swiss stations.

ERNEST TILLOTSON

EDUCATION IN INDIA

THE first elections in free India under universal suffrage showed that a large proportion of voters had voted not for any particular cause, or person, but for the sacred bull (*Science and Culture*, 18, No. 1; July 1952). Congress, which now holds power, had long been mindful of the importance of educational reforms. So far back as the Karachi session of the Indian National Congress of 1931, a resolution was passed defining the fundamental rights of citizens and stating in its preamble that to enable the masses to appreciate what Swaraj would mean to them, Congress should provide for free and compulsory education.

Since independence, the National Government has been seriously tackling this problem. A large number of committees was appointed to consider general educational matters. Among them was the Kher Committee, which recommended that: (1) a fixed percentage of central and provincial revenues—about 10 per cent of the central and 20 per cent of the provincial—should be earmarked for education by the respective Governments; (2) about 70 per cent of the expenditure on education should be borne by Provincial Governments, including local bodies, and the remaining 30 per cent by the Central Government; (3) all contributions for education approved by the Provincial and Central Governments should be exempted from income tax.

The percentages recommended by the Kher Committee were not large. In certain States of the United States of America, nearly 30 per cent is spent on education, and in one State nearly 40 per cent. Apart from Mysore, which was already spending a larger percentage on education, no other major State, excepting a few like Bombay and Madras, have given serious attention to the Kher Committee's recommendations.

A comparison of State finances for 1951–52 shows that the total educational budget of all the States amounted to Rs. 65 crores, which is about 14·8 per cent of the total budgets of the various States against the Kher Committee's recommendation of 20 per cent. From these figures it is clear that the attempts to remove 'illiteracy' in the Indian Union has fallen short of the objective of Congress.

When Shri B. G. Kher's Committee recommended that 10 per cent of the central budget should be spent on education, it was implied that the bulk of it should be spent on higher and professional education. Ten per cent of the central budget comes to 30–40 crores of rupees, while the actual expenditure by the Central Government has varied between 3 and 6 crores.

The University Commission, appointed by Government on November 4, 1948, supported the National Planning Committee and Kher Committee's recommendation that democracy depends for its very life on a high standard of general, vocational and professional education. The academic problem has assumed new shapes. India now has a wider conception of the duties and responsibilities of universities. "They have to provide leadership in politics, administration, the professions, industry and commerce. They have to meet the increasing demand for every type of higher education, literary and scientific, technical and professional. It is for the universities to create knowledge and train minds who would bring together material resources and human energies."

The Commission found that the universities were unable to carry out these responsibilities because their finances were totally inadequate.

Like the Kher Committee, it recommended that the Central Government should make large grants for higher education through a properly constituted agency.

The Commission is aware that the Central Government has taken the responsibility of maintaining the Universities of Banaras, Aligarh and Delhi (and now, the Visva Bharati), and that a large amount of money has been given as grants to meet the needs of these universities. While welcoming and appreciating the grants that have so far been given, the Commission has suggested that, even though grants to other universities are mainly provincial responsibilities, they should also be the concern of the Central Government at least so far as postgraduate education and

research are concerned. The Commission noted with appreciation that grants to universities have been given by the Government of India in recent years, but hoped that there would be a more systematized method of giving these grants on the advice of a responsible body.

MICROSOMAL PARTICLES OF NORMAL COW'S MILK

By Dr. R. K. MORTON

Biochemical Laboratory, University of Cambridge*

HITHERTO, cow's milk has been considered to contain particulate components belonging to three categories, namely: (1) blood cells, leucocytes, bacteria and other readily sedimentable 'foreign' material; (2) butterfat globules; and (3) particles of the casein – calcium phosphate complex. However, it has recently been shown that lipoprotein particles, with which the alkaline phosphatase is firmly associated, also occur in milk[1,2]. Disruption of the lipid-protein bonds by treatment with *n*-butanol releases the alkaline phosphatase into true solution[1,3].

In order to obtain the lipoprotein particles, whole milk was centrifuged (2,500 *g*, 45 min.) and the cream layer removed and repeatedly washed with distilled water. After churning, the buttermilk so obtained was centrifuged at high speed (14,000 *g*, 45 min.). The red-brown lipoprotein precipitate was then dispersed in distilled water.

The separated milk was also centrifuged under similar conditions to obtain a pure white precipitate of casein. In this way both the lipoprotein and casein complexes were isolated by methods expected to produce only a minimum of denaturation or other modification, although the recovery was by no means quantitative.

The properties of the two materials are compared in the accompanying table.

Comparative Properties of Casein and Lipoprotein Particles of Normal Cow's Milk

	Casein particles	Lipoprotein particles
Lipid (per cent)	3	22
Nucleic acid	Not determined	Present
Cytochrome *c*	Absent	Present
Enzymic activities:		
Alkaline phosphatase	0·6	57·2
Diaphorase	Absent	2·5
Coenzyme I–cytochrome *c* reductase	Absent	0·1
Xanthine oxidase	Absent	37·7
Succinic dehydrogenase	Absent	Absent
Cytochrome oxidase	Absent	Absent

Units for enzymic activities: alkaline phosphatase expressed as μmole phosphorus liberated from β-glycerophosphate/hr./mgm. nitrogen (at 37° C.); dehydrogenases expressed as μmole 2 : 6-dichlorophenol indophenol (diaphorase and xanthine oxidase) or of cytochrome *c* (coenzyme I–cytochrome *c* reductase) reduced/hr./mgm. nitrogen (at 18° C.)

The difference between the two protein complexes is immediately apparent. The relatively high lipid content (most of which is phospholipid) and the considerable enzymic activity of the lipoprotein preparation suggests that this was obtained relatively free of contaminant casein. Moreover, the very low enzymic activity of the casein precipitate indicates that it was only slightly contaminated with lipoprotein particles.

* Present address: Department of Biochemistry, University of Melbourne, Australia.

Partial separation of the casein from the lipoprotein particles has also been obtained by removing the former as paracasein by the action of crystalline rennin. However, other methods of separation, such as by precipitation of casein at the isoelectric point, with salts or with organic solvents, result in co-precipitation of the lipoprotein particles. Hence casein prepared by these methods will always contain this lipoprotein impurity, which may account for some of the heterogeneity ascribed to so-called 'purified' casein[4].

The chemical and enzymic characteristics of the lipoprotein complex as shown in the table are very similar to those of the microsomal particles from animal tissues[5]. Therefore, it is considered that these lipoprotein particles of normal cow's milk should be called 'milk microsomes'. Furthermore, since the alkaline phosphatases of milk and of mammary gland are identical, it appears that the microsomes are released into the milk from the secretory cells of the gland. The isolation of microsomes from an animal secretion without prior homogenization or other disruptive treatment indicates that these particles occur as such in the cells.

Microsomes have been considered to be derived by fragmentation of mitochondria[5,6]. However, it is clear that the milk microsomes could not have been obtained in this way. The failure to demonstrate either succinic dehydrogenase or cytochrome oxidase in any of the precipitates from milk indicates that mitochondria (with which these enzymes are firmly associated) are virtually absent. They apparently are not released into milk during normal secretion. The significance of the presence of microsomes and absence of mitochondria is the subject of further investigation.

The factors which influence the release of microsomes into milk from the secretory cells of the mammary gland have not yet been studied. It seems likely, however, that more microsomes will be released during disturbance of normal functioning of the gland, as, for example, during mastitis infection, or towards the end of lactation. The alkaline phosphatase activity of milk rises under both these influences[7,8]. Thiouracil treatment also increases the phosphatase activity of milk[9,10], in contrast to thyroxine[11]. It seems very probable that these compounds affect the release of the milk microsomes, rather than the phosphatase activity of the microsomes themselves. Therefore, caution is urged against concluding that the change in activity of milk is an indication of similar changes in the enzymic activity of the mammary gland itself[9,10].

The association of xanthine oxidase activity with microsomal particles has not previously been demonstrated. It is therefore of interest that microsomes from liver have also been found to have high activity. It now seems important to determine whether the properties of the particle-bound xanthine oxidases differ from those of the flavoprotein obtained in solution either by proteolytic or lipolytic action[12] or by butanol treatment[1].

Electron micrographs of the casein particles and the milk microsomes have shown that both are spheroidal in shape. The microsomes, however, do not show the same tendency to clump in regular forms as do the casein particles; they are much less dense and they often appear somewhat flattened. Both types of particles vary in size, from a maximum of about 250 mμ diameter, diminishing beyond the limits of resolution with the equipment available (less than 30 mμ).

In endeavouring to obtain an active preparation of the 'virus' responsible for transmissible carcinoma in mice, different workers have employed centrifuging, either of untreated milk[13,14], or of milk after coagulation of casein with chymotrypsin[15]. The precipitates so obtained would certainly contain both casein and microsomal particles, the latter predominating where chymotrypsin treatment was used. Comparison of the electron micrographs obtained in the present work with those of particles separated from milk of mice having mammary carcinoma[13-15] confirms this view. Consequently, the claim that virus particles have been demonstrated in the sedimented material from infective milk cannot be considered as established. Moreover, the apparent relationship between the occurrence of human breast carcinoma and the number of particles found in milk[16] might well be explained by the release of a greater number of microsomes into milk from diseased cells. This would become particularly apparent in human milk, since the casein content (0·5 per cent) is so very much lower than that of cow's milk (3 per cent). The possibility that the milk microsomes themselves may carry the infective agent which is concerned in inducing carcinoma in susceptible mice is at present being investigated.

I wish to thank Mr. R. W. Horne, formerly of the Cavendish Laboratory, Cambridge, for taking the electron micrographs. I am grateful to Dr. M. Dixon for his continued interest and advice in this work, and to the Gowrie Scholarship Trust Fund of Australia and the Agricultural Research Council of Great Britain for financial support.

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MEASUREMENT OF WIND CURRENTS IN THE SEA BY THE METHOD OF TOWED ELECTRODES

By K. F. BOWDEN
National Institute of Oceanography

IT was first pointed out by Faraday that when a stream of water flows through the earth's magnetic field an electromotive force should be induced in it. Experiments made by Faraday himself, by suspending electrodes in the River Thames from Waterloo Bridge, failed to detect this e.m.f., owing to polarization of the electrodes and other experimental difficulties. Since then, measurements made on various submarine cables showed voltages related to the velocities of the tidal streams in their vicinity. In 1918, Young, Gerrard and Jevons[1] carried out experiments in the English Channel, using both fixed electrodes and electrodes towed in tandem behind a vessel. Their experiments showed clearly the existence of the induced e.m.f.'s due to tidal currents. In 1946, Longuet-Higgins[2] made measurements of the potential differences across pairs of fixed electrodes in the English Channel and gave a theoretical treatment of the potential gradients generated by water flow in a shallow channel. Since 1946 a form of equipment using towed electrodes, and known as the geomagnetic electro-kinetograph (G.E.K.), has been developed in the United States and used in a number of U.S. oceanographic and survey vessels to determine surface currents in the ocean (Von Arx[3]). The method of towed electrodes has also been used during recent cruises of the R.R.S. *Discovery II*, using quite simple equipment.

If a stream of water is moving horizontally with a velocity of V cm./sec. and the vertical component of the earth's magnetic intensity is Z gauss, then the e.m.f. induced in a filament of water of length l cm., transverse to the direction of flow, is given by

$$E = VZl \times 10^{-8} \text{ volt.} \qquad (1)$$

Its direction is from right to left, in the northern magnetic hemisphere, as one faces downstream. If there is a conducting return path below the moving water, a current will flow, the current density i being given by

$$i = E/(\rho + \rho')l,$$

where ρ is the specific resistance of the moving water, and ρ' may be termed the effective specific resistance of the return path. Then the potential difference measured by a voltmeter connected across a pair of fixed electrodes, distant l apart, would be

$$e_1 = E - \rho li = E[1 - \rho/(\rho + \rho')]. \qquad (2)$$

If, however, the electrodes and the voltmeter are attached to a vessel drifting with the water, an e.m.f. E will also be induced directly in the connecting wires, and the potential difference actually measured, e_2, will be the difference between this and the potential difference in the water, that is:

$$e_2 = e_1 - E = -\rho li = -\rho E/(\rho + \rho'). \qquad (3)$$

It is seen that the method of drifting electrodes is most sensitive when $\rho' \ll \rho$. This is the case when the flow extends only to a depth which is small compared with the total depth of water, so that the lower layer of water acts as a low-resistance return path for the electric current.

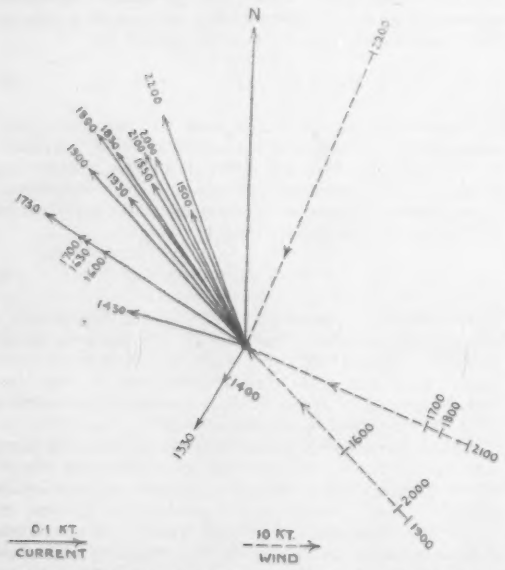
In the towed-electrode equipment used in *Discovery II*, the electrodes are of the non-polarizing silver/silver-chloride type, packed in glass wool in a cylindrical 'Tufnol' casing, which contains a number of holes to allow access to the water. A two-core rubber-covered cable serves for making electrical connexion to the electrodes and for towing them. The distance between the electrodes is usually 100 yd. and, with this separation, the sensitivity is approximately 2 millivolts per knot when Z is about 0·4

gauss. On board, the two conductors are connected to the input of a D.C. amplifier, the output of which operates a pen recorder. A resistance-capacitance filter, with a time constant of approximately 30 sec., may be connected across the input to the amplifier, to reduce signals due to the component of particle velocity of the waves.

When the electrodes are being towed, the potential difference measured depends on the component of drift of the ship and electrode system at right-angles to the direction of towing, the forward speed of the ship being immaterial. By making observations on two courses at right-angles, the drift of the surface water may be determined in magnitude and direction. It is also necessary that a change of course of 180° should be made periodically to determine the 'zero point' of the potential difference and eliminate slow changes in the electro-chemical potentials of the electrodes. One way of fulfilling these conditions is by steaming in squares, that is, changing course by 90° at regular intervals.

The towed-electrodes method is well suited to the measurement of wind drift in deep water, since the drift is unlikely to extend to a depth greater than about 50 fathoms. An example of its use for this purpose, showing the development of a drift current following a change in the wind, was obtained during a recent cruise of *Discovery II*. At noon on October 12, 1952, *Discovery II* was in position 47° 50′ N., 12° 30′ W., in a depth of about 2,400 fm. After blowing from west-north-west during the morning, the wind had dropped to 'light airs' by noon. Soon afterwards, it started to blow from the south-east and freshened, reaching an average speed of 18 knots by 1600 hr., 25 knots at 1700 hr. and 30 knots at 1900 hr. A series of towed-electrode measurements was started at 1230 hr., the vessel steaming in squares, changing course by 90° every half-hour.

The accompanying diagram shows, in vector form, the drift currents as computed from these measurements. Each full-line arrow shows the direction and speed of drift, as computed from measurements on the four legs of a square, obtained during the period of 2 hr. centred on the time marked against the arrow. The corresponding wind vectors are shown by the broken-line arrows.



Discovery II, October 12, 1952. Current vectors, derived from towed electrode observations, and corresponding wind vectors. The time of observation is marked against each vector. At 1200 hr. the wind was reported as "light airs" and at 2130 hr. as "variable, 10 to 25 kt."

The 1330-hr. vector shows the drift as 0·12 knot, setting approximately towards south-south-west, and at 1400 hr. the drift had decreased to 0·05 knot in the same direction. The 1430-hr. vector, however, shows a drift of 0·16 knot in direction west by north. Subsequent vectors show the drift to be turning farther towards north-west and increasing in magnitude. By 1730 hr. the speed was 0·30 knot, bearing 301° (true). Afterwards the speed did not increase appreciably, although the direction continued to veer. Between 1800 and 2200 hr., the direction varied between 316° and 338°; but the variations are probably within the experimental error. Taking the mean of the determinations from 1800 to 2200 hr., the drift was 0·29 knot in direction 326°. The mean of the wind determinations from 1700 to 2100 hr. was 28 knots, blowing towards direction 308°. Thus the magnitude of the drift was about 1·0 per cent of the wind speed and its direction 18° to the right of the wind. After 2100 hr. the wind dropped, and at 2130 hr. was 10–25 knots, variable in direction. By 2200 hr. it had backed to north-north-east and increased to 40 knots. It appears from the meteorological charts that the centre of a small, but intense, depression passed slightly to the south of the ship's position at 2100 hr. The 2200-hr. drift vector (based on measurements taken between 2100 and 2300 hr.) shows no response to the change in wind direction, and could scarcely be expected to do so.

It is of interest to compare these observations with the classical theory of wind drift, due to Ekman[4]. According to the theory, the surface drift, after the steady state has been reached, should be 45° to the right of the wind (in the northern hemisphere) and its magnitude v_s should be given by

$$v_s = 0{\cdot}0127\ W\ (\sin\varphi)^{-1/2},$$

where W is the wind speed and φ the latitude. Taking $\varphi = 48°$, gives $v_s = 0{\cdot}0148\ W$. If the water is initially at rest and a wind suddenly starts to blow and then remains steady, the surface current should reach a speed comparable with the steady-state value after about 2½ hr., in this latitude. The direction of the surface current should approach its final value more slowly, and after 2½ hr. should be approximately 18° to the right of the wind.

The observed drift had a speed only about two-thirds of that predicted by theory for a current generated by the local wind. The discrepancy may be due, in part, to the presence of another current constituent which is independent of, or less readily affected by, the local wind. Current charts indicate that, in this part of the north-east Atlantic, there is a general drift towards the south-east, which would be almost directly opposed to the wind drift observed on October 12, and would thus reduce its magnitude.

These observations illustrate the rapid response of the surface drift to a change in wind and show that such changes in drift may readily be determined by the towed-electrodes method, using simple recording apparatus.

Acknowledgment is made to Dr. J. T. Crennell, of the Admiralty Chemical Laboratory, for advice on the design and construction of the electrodes, to Mr. M. J. Tucker, who was responsible for the electronic

equipment, and to Dr. G. E. R. Deacon and the captain and officers of R.R.S. *Discovery II* for their part in making the observations.

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MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.

This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the *z*-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical *z*-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at

King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. Watson
F. H. C. Crick
Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.
April 2.

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Molecular Structure of Deoxypentose Nucleic Acids

While the biological properties of deoxypentose nucleic acid suggest a molecular structure containing great complexity, X-ray diffraction studies described here (cf. Astbury[1]) show the basic molecular configuration has great simplicity. The purpose of this communication is to describe, in a preliminary way, some of the experimental evidence for the polynucleotide chain configuration being helical, and existing in this form when in the natural state. A fuller account of the work will be published shortly.

The structure of deoxypentose nucleic acid is the same in all species (although the nitrogen base ratios alter considerably) in nucleoprotein, extracted or in cells, and in purified nucleate. The same linear group of polynucleotide chains may pack together parallel in different ways to give crystalline[1–3], semi-crystalline or paracrystalline material. In all cases the X-ray diffraction photograph consists of two regions, one determined largely by the regular spacing of nucleotides along the chain, and the other by the longer spacings of the chain configuration. The sequence of different nitrogen bases along the chain is not made visible.

Oriented paracrystalline deoxypentose nucleic acid ('structure *B*' in the following communication by Franklin and Gosling) gives a fibre diagram as shown in Fig. 1 (cf. ref. 4). Astbury suggested that the strong 3·4-A. reflexion corresponded to the inter-nucleotide repeat along the fibre axis. The ~ 34 A. layer lines, however, are not due to a repeat of a polynucleotide composition, but to the chain configuration repeat, which causes strong diffraction as the nucleotide chains have higher density than the interstitial water. The absence of reflexions on or near the meridian immediately suggests a helical structure with axis parallel to fibre length.

Diffraction by Helices

It may be shown[5] (also Stokes, unpublished) that the intensity distribution in the diffraction pattern of a series of points equally spaced along a helix is given by the squares of Bessel functions. A uniform continuous helix gives a series of layer lines of spacing corresponding to the helix pitch, the intensity distribution along the nth layer line being proportional to the square of J_n, the nth order Bessel function. A straight line may be drawn approximately through

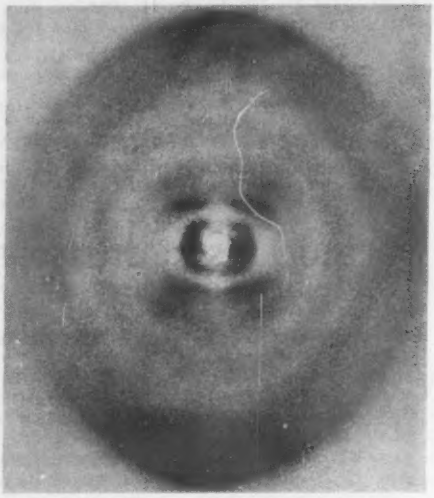

Fig. 1. Fibre diagram of deoxypentose nucleic acid from *B. coli*. Fibre axis vertical

the innermost maxima of each Bessel function and the origin. The angle this line makes with the equator is roughly equal to the angle between an element of the helix and the helix axis. If a unit repeats n times along the helix there will be a meridional reflexion (J_0^2) on the nth layer line. The helical configuration produces side-bands on this fundamental frequency, the effect[5] being to reproduce the intensity distribution about the origin around the new origin, on the nth layer line, corresponding to C in Fig. 2.

We will now briefly analyse in physical terms some of the effects of the shape and size of the repeat unit or nucleotide on the diffraction pattern. First, if the nucleotide consists of a unit having circular symmetry about an axis parallel to the helix axis, the whole diffraction pattern is modified by the form factor of the nucleotide. Second, if the nucleotide consists of a series of points on a radius at right-angles to the helix axis, the phases of radiation scattered by the helices of different diameter passing through each point are the same. Summation of the corresponding Bessel functions gives reinforcement for the inner-

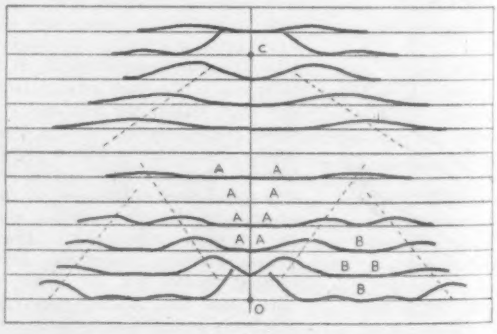

Fig. 2. Diffraction pattern of system of helices corresponding to structure of deoxypentose nucleic acid. The squares of Bessel functions are plotted about 0 on the equator and on the first, second, third and fifth layer lines for half of the nucleotide mass at 20 A. diameter and remainder distributed along a radius, the mass at a given radius being proportional to the radius. About C on the tenth layer line similar functions are plotted for an outer diameter of 12 A.

most maxima and, in general, owing to phase difference, cancellation of all other maxima. Such a system of helices (corresponding to a spiral staircase with the core removed) diffracts mainly over a limited angular range, behaving, in fact, like a periodic arrangement of flat plates inclined at a fixed angle to the axis. Third, if the nucleotide is extended as an arc of a circle in a plane at right-angles to the helix axis, and with centre at the axis, the intensity of the system of Bessel function layer-line streaks emanating from the origin is modified owing to the phase differences of radiation from the helices drawn through each point on the nucleotide. The form factor is that of the series of points in which the helices intersect a plane drawn through the helix axis. This part of the diffraction pattern is then repeated as a whole with origin at *C* (Fig. 2). Hence this aspect of nucleotide shape affects the central and peripheral regions of each layer line differently.

Interpretation of the X-Ray Photograph

It must first be decided whether the structure consists of essentially one helix giving an intensity distribution along the layer lines corresponding to $J_1, J_2, J_3 \ldots$, or two similar co-axial helices of twice the above size and relatively displaced along the axis a distance equal to half the pitch giving $J_2, J_4, J_6 \ldots$, or three helices, etc. Examination of the width of the layer-line streaks suggests the intensities correspond more closely to J_1^2, J_2^2, J_3^2 than to $J_2^2, J_4^2, J_6^2 \ldots$ Hence the dominant helix has a pitch of ~ 34 A., and, from the angle of the helix, its diameter is found to be ~ 20 A. The strong equatorial reflexion at ~ 17 A. suggests that the helices have a maximum diameter of ~ 20 A. and are hexagonally packed with little interpenetration. Apart from the width of the Bessel function streaks, the possibility of the helices having twice the above dimensions is also made unlikely by the absence of an equatorial reflexion at ~ 34 A. To obtain a reasonable number of nucleotides per unit volume in the fibre, two or three intertwined coaxial helices are required, there being ten nucleotides on one turn of each helix.

The absence of reflexions on or near the meridian (an empty region *AAA* on Fig. 2) is a direct consequence of the helical structure. On the photograph there is also a relatively empty region on and near the equator, corresponding to region *BBB* on Fig. 2. As discussed above, this absence of secondary Bessel function maxima can be produced by a radial distribution of the nucleotide shape. To make the layer-line streaks sufficiently narrow, it is necessary to place a large fraction of the nucleotide mass at ~ 20 A. diameter. In Fig. 2 the squares of Bessel functions are plotted for half the mass at 20 A. diameter, and the rest distributed along a radius, the mass at a given radius being proportional to the radius.

On the zero layer line there appears to be a marked J_{10}^2, and on the first, second and third layer lines, $J_9^2 + J_{11}^2$, $J_8^2 + J_{12}^2$, etc., respectively. This means that, in projection on a plane at right-angles to the fibre axis, the outer part of the nucleotide is relatively concentrated, giving rise to high-density regions spaced *c.* 6 A. apart around the circumference of a circle of 20 A. diameter. On the fifth layer line two J_5 functions overlap and produce a strong reflexion. On the sixth, seventh and eighth layer lines the maxima correspond to a helix of diameter ~ 12 A. Apparently it is only the central region of the helix structure which is well divided by the 3·4-A. spacing, the outer parts of the nucleotide overlapping to form a continuous helix. This suggests the presence of nitrogen bases arranged like a pile of pennies[1] in the central regions of the helical system.

There is a marked absence of reflexions on layer lines beyond the tenth. Disorientation in the specimen will cause more extension along the layer lines of the Bessel function streaks on the eleventh, twelfth and thirteenth layer lines than on the ninth, eighth and seventh. For this reason the reflexions on the higher-order layer lines will be less readily visible. The form factor of the nucleotide is also probably causing diminution of intensity in this region. Tilting of the nitrogen bases could have such an effect.

Reflexions on the equator are rather inadequate for determination of the radial distribution of density in the helical system. There are, however, indications that a high-density shell, as suggested above, occurs at diameter ~ 20 A.

The material is apparently not completely paracrystalline, as sharp spots appear in the central region of the second layer line, indicating a partial degree of order of the helical units relative to one another in the direction of the helix axis. Photographs similar to Fig. 1 have been obtained from sodium nucleate from calf and pig thymus, wheat germ, herring sperm, human tissue and T_2 bacteriophage. The most marked correspondence with Fig. 2 is shown by the exceptional photograph obtained by our colleagues, R. E. Franklin and R. G. Gosling, from calf thymus deoxypentose nucleate (see following communication).

It must be stressed that some of the above discussion is not without ambiguity, but in general there appears to be reasonable agreement between the experimental data and the kind of model described by Watson and Crick (see also preceding communication).

It is interesting to note that if there are ten phosphate groups arranged on each helix of diameter 20 A. and pitch 34 A., the phosphate ester backbone chain is in an almost fully extended state. Hence, when sodium nucleate fibres are stretched[3], the helix is evidently extended in length like a spiral spring in tension.

Structure *in vivo*

The biological significance of a two-chain nucleic acid unit has been noted (see preceding communication). The evidence that the helical structure discussed above does, in fact, exist in intact biological systems is briefly as follows:

Sperm heads. It may be shown that the intensity of the X-ray spectra from crystalline sperm heads is determined by the helical form-function in Fig. 2. Centrifuged trout semen give the same pattern as the dried and rehydrated or washed sperm heads used previously[4]. The sperm head fibre diagram is also given by extracted or synthetic[1] nucleoprotamine or extracted calf thymus nucleohistone.

Bacteriophage. Centrifuged wet pellets of T_2 phage photographed with X-rays while sealed in a cell with mica windows give a diffraction pattern containing the main features of paracrystalline sodium nucleate as distinct from that of crystalline nucleoprotein. This confirms current ideas of phage structure.

Transforming principle (in collaboration with H. Ephrussi-Taylor). Active deoxypentose nucleate allowed to dry at ~ 60 per cent humidity has the same crystalline structure as certain samples[5] of sodium thymonucleate.

We wish to thank Prof. J. T. Randall for encouragement; Profs. E. Chargaff, R. Signer, J. A. V. Butler and Drs. J. D. Watson, J. D. Smith, L. Hamilton, J. C. White and G. R. Wyatt for supplying material without which this work would have been impossible; also Drs. J. D. Watson and Mr. F. H. C. Crick for stimulation, and our colleagues R. E. Franklin, R. G. Gosling, G. L. Brown and W. E. Seeds for discussion. One of us (H. R. W.) wishes to acknowledge the award of a University of Wales Fellowship.

M. H. F. Wilkins
Medical Research Council Biophysics Research Unit,

A. R. Stokes
H. R. Wilson
Wheatstone Physics Laboratory, King's College, London.
April 2.

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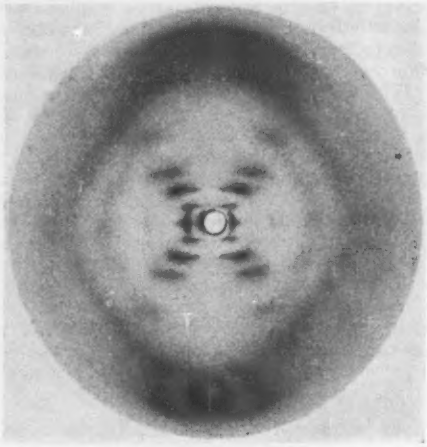
Molecular Configuration in Sodium Thymonucleate

Sodium thymonucleate fibres give two distinct types of X-ray diagram. The first corresponds to a crystalline form, structure *A*, obtained at about 75 per cent relative humidity; a study of this is described in detail elsewhere[1]. At higher humidities a different structure, structure *B*, showing a lower degree of order, appears and persists over a wide range of ambient humidity. The change from *A* to *B* is reversible. The water content of structure *B* fibres which undergo this reversible change may vary from 40–50 per cent to several hundred per cent of the dry weight. Moreover, some fibres never show structure *A*, and in these structure *B* can be obtained with an even lower water content.

The X-ray diagram of structure *B* (see photograph) shows in striking manner the features characteristic of helical structures, first worked out in this laboratory by Stokes (unpublished) and by Crick, Cochran and Vand[5]. Stokes and Wilkins were the first to propose such structures for nucleic acid as a result of direct studies of nucleic acid fibres, although a helical structure had been previously suggested by Furberg (thesis, London, 1949) on the basis of X-ray studies of nucleosides and nucleotides.

While the X-ray evidence cannot, at present, be taken as direct proof that the structure is helical, other considerations discussed below make the existence of a helical structure highly probable.

Structure *B* is derived from the crystalline structure *A* when the sodium thymonucleate fibres take up quantities of water in excess of about 40 per cent of their weight. The change is accompanied by an increase of about 30 per cent in the length of the fibre, and by a substantial re-arrangement of the molecule. It therefore seems reasonable to suppose that in structure *B* the structural units of sodium thymonucleate (molecules on groups of molecules) are relatively free from the influence of neighbouring



Sodium deoxyribose nucleate from calf thymus. Structure *B*

molecules, each unit being shielded by a sheath of water. Each unit is then free to take up its least-energy configuration independently of its neighbours and, in view of the nature of the long-chain molecules involved, it is highly likely that the general form will be helical[3]. If we adopt the hypothesis of a helical structure, it is immediately possible, from the X-ray diagram of structure *B*, to make certain deductions as to the nature and dimensions of the helix.

The innermost maxima on the first, second, third and fifth layer lines lie approximately on straight lines radiating from the origin. For a smooth single-strand helix the structure factor on the nth layer line is given by:

$$F_n = J_n(2\pi rR) \exp i\, n(\psi + \tfrac{1}{2}\pi),$$

where $J_n(u)$ is the nth-order Bessel function of u, r is the radius of the helix, and R and ψ are the radial and azimuthal co-ordinates in reciprocal space[2]; this expression leads to an approximately linear array of intensity maxima of the type observed, corresponding to the first maxima in the functions J_1, J_2, J_3, etc.

If, instead of a smooth helix, we consider a series of residues equally spaced along the helix, the transform in the general case treated by Crick, Cochran and Vand is more complicated. But if there is a whole number, m, of residues per turn, the form of the transform is as for a smooth helix with the addition, only, of the same pattern repeated with its origin at heights mc^*, $2mc^*$ . . . etc. (c is the fibre-axis period).

In the present case the fibre-axis period is 34 A. and the very strong reflexion at 3·4 A. lies on the tenth layer line. Moreover, lines of maxima radiating from the 3·4-A. reflexion as from the origin are visible on the fifth and lower layer lines, having a J_3 maximum coincident with that of the origin series on the fifth layer line. (The strong outer streaks which apparently radiate from the 3·4-A. maximum are not, however, so easily explained.) This suggests strongly that there are exactly 10 residues per turn of the helix. If this is so, then from a measurement of R_n the position of the first maximum on the nth layer line (for n 5≮), the radius of the helix, can be obtained. In the present instance, measurements of R_1, R_2, R_3 and R_5 all lead to values of r of about 10 A.

Since this linear array of maxima is one of the strongest features of the X-ray diagram, we must conclude that a crystallographically important part of the molecule lies on a helix of this diameter. This can only be the phosphate groups or phosphorus atoms.

If ten phosphorus atoms lie on one turn of a helix of radius 10 A., the distance between neighbouring phosphorus atoms in a molecule is 7·1 A. This corresponds to the P . . . P distance in a fully extended molecule, and therefore provides a further indication that the phosphates lie on the outside of the structural unit.

Thus, our conclusions differ from those of Pauling and Corey[4], who proposed for the nucleic acids a helical structure in which the phosphate groups form a dense core.

We must now consider briefly the equatorial reflexions. For a single helix the series of equatorial maxima should correspond to the maxima in $J_0(2\pi rR)$. The maxima on our photograph do not, however, fit this function for the value of r deduced above. There is a very strong reflexion at about 24 A. and then only a faint sharp reflexion at 9·0 A. and two diffuse bands around 5·5 A. and 4·0 A. This lack of agreement is, however, to be expected, for we know that the helix so far considered can only be the most important member of a series of coaxial helices of different radii; the non-phosphate parts of the molecule will lie on inner co-axial helices, and it can be shown that, whereas these will not appreciably influence the innermost maxima on the layer lines, they may have the effect of destroying or shifting both the equatorial maxima and the outer maxima on other layer lines.

Thus, if the structure is helical, we find that the phosphate groups or phosphorus atoms lie on a helix of diameter about 20 A., and the sugar and base groups must accordingly be turned inwards towards the helical axis.

Considerations of density show, however, that a cylindrical repeat unit of height 34 A. and diameter 20 A. must contain many more than ten nucleotides.

Since structure *B* often exists in fibres with low water content, it seems that the density of the helical unit cannot differ greatly from that of dry sodium thymonucleate, 1·63 gm./cm.^{3} [1,5], the water in fibres of high water-content being situated outside the structural unit. On this basis we find that a cylinder of radius 10 A. and height 34 A. would contain thirty-two nucleotides. However, there might possibly be some slight inter-penetration of the cylindrical units in the dry state making their effective radius rather less. It is therefore difficult to decide, on the basis of density measurements alone, whether one repeating unit contains ten nucleotides on each of two or on each of three co-axial molecules. (If the effective radius were 8 A. the cylinder would contain twenty nucleotides.) Two other arguments, however, make it highly probable that there are only two co-axial molecules.

First, a study of the Patterson function of structure *A*, using superposition methods, has indicated[6] that there are only two chains passing through a primitive unit cell in this structure. Since the $A \rightleftharpoons B$ transformation is readily reversible, it seems very unlikely that the molecules would be grouped in threes in structure *B*. Secondly, from measurements on the X-ray diagram of structure *B* it can readily be shown that, whether the number of chains per unit is two or three, the chains are not equally spaced along the fibre axis. For example, three equally spaced chains would mean that the nth layer line depended on J_{3n}, and would lead to a helix of diameter about 60 A. This is many times larger than the primitive unit cell in structure *A*, and absurdly large in relation to the dimensions of nucleotides. Three unequally spaced chains, on the other hand, would be crystallographically non-equivalent, and this, again, seems unlikely. It therefore seems probable that there are only two co-axial molecules and that these are unequally spaced along the fibre axis.

Thus, while we do not attempt to offer a complete interpretation of the fibre-diagram of structure *B*, we may state the following conclusions. The structure is probably helical. The phosphate groups lie on the outside of the structural unit, on a helix of diameter about 20 A. The structural unit probably consists of two co-axial molecules which are not equally spaced along the fibre axis, their mutual displacement being such as to account for the variation of observed intensities of the innermost maxima on the layer lines; if one molecule is displaced from the other by about three-eighths of the fibre-axis period, this would account for the absence of the fourth layer line maxima and the weakness of the sixth. Thus our general ideas are not inconsistent with the model proposed by Watson and Crick in the preceding communication.

The conclusion that the phosphate groups lie on the outside of the structural unit has been reached previously by quite other reasoning[1]. Two principal lines of argument were invoked. The first derives from the work of Gulland and his collaborators[7], who showed that even in aqueous solution the —CO and —NH_2 groups of the bases are inaccessible and cannot be titrated, whereas the phosphate groups are fully accessible. The second is based on our own observations[1] on the way in which the structural units in structures *A* and *B* are progressively separated by an excess of water, the process being a continuous one which leads to the formation first of a gel and ultimately to a solution. The hygroscopic part of the molecule may be presumed to lie in the phosphate groups ($(C_5H_6O)_3PO_3Na$ and $(C_2H_7O)_3PO_3Na$ are highly hygroscopic[8]), and the simplest explanation of the above process is that these groups lie on the outside of the structural units. Moreover, the ready availability of the phosphate groups for interaction with proteins can most easily be explained in this way.

We are grateful to Prof. J. T. Randall for his interest and to Drs. F. H. C. Crick, A. R. Stokes and M. H. F. Wilkins for discussion. One of us (R. E. F.) acknowledges the award of a Turner and Newall Fellowship.

ROSALIND E. FRANKLIN*
R. G. GOSLING

Wheatstone Physics Laboratory,
King's College, London.
April 2.

* Now at Birkbeck College Research Laboratories, 21 Torrington Square, London, W.C.1.

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LETTERS TO THE EDITORS

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Vertical Distribution of Radium in Deep-Sea Sediments

The surprisingly high content of radium in certain deep-sea sediments discovered nearly fifty years ago by J. Joly[1] remained unexplained until 1937, when H. Pettersson[2] suggested an ocean-wide precipitation of ionium from sea water on to the ocean bottom as its origin. Extensive radium measurements on deep-sea cores raised by the Swedish Deep-Sea Expedition carried out in this institute by Pettersson[3], T. Bernert[4] and me did not confirm the regular vertical distribution of radium reported by other workers[5]. An expected rise in radium content from moderate values in the uppermost surface layers to a maximum corresponding to a radioactive equilibrium between precipitated ionium and ionium-supported radium generally occurred; but the maximum was not followed by the theoretical exponential decline downwards governed by the rate of decay of ionium, to 50 per cent in 83,000 years, to 25 per cent in 166,000 years, etc. Instead, a number of secondary maxima of radium content separated by equally pronounced minima were observed (see graph), which could not well be explained as due to intervening changes in the rate of total sedimentation. Another explanation offered was that ionium and radium are not in radioactive equilibrium; that is, the assumption underlying the use of measurements of radium as indicating the concentration in the same layer of its mother element is unjustified.

Radium is well known for its migratory habits, leading to high concentrations of the element in manganese nodules. It was, therefore, decided to ask the assistance of a specialist on the photographic method—Dr. E. Picciotto, of the Centre for Nuclear Research in Brussels—to develop a method suitable for direct determinations of the content of ionium in the sediment. These attempts have met with success, as is seen from the following communication by Dr. E. Picciotto and Miss N. Isaac. So far, only a limited number of samples from Pacific red clay have been measured; but already the present results lend support to the conclusion that the greater part of the radium in the sediment is ionium-supported, and the migration of radium is proved.

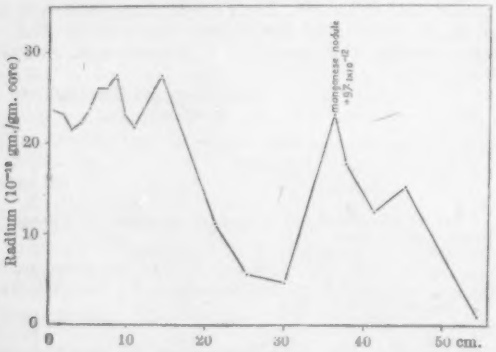
However, interesting results can also be obtained from the radium measurements. Thus an integration of the total radium content in a sediment core down to levels (L_0) where practically all the ionium precipitated has had time to become disintegrated, so that generally only very small quantities of uranium-supported radium are present, permits a comparison between the excess radium in the upper sediment layers and the potential supply of radium derivable from the uranium in the superposed column of sea water. Although both figures are of the same order of magnitude, there appears to be a surplus of sediment radium over that to be expected from ionium precipitation by a factor of 1·5–3. This discrepancy, which evidently falls outside the limits of experimental error, may possibly be due to a considerably higher content of dissolved uranium in the ocean during late quaternary time than at present (namely, $1{\cdot}3 \times 10^{-6}$ gm. radium/litre[6]).

Having found through such an integration of the total radium content the corresponding value for the total ionium content in the sediment column, a theoretical value of the ionium content at L_0 can be calculated by assuming that the column L_0 is precipitated during a certain period of time (for example, 330,000 years = 4 half-periods of ionium). The time correlation is now varied until the calculated ionium content at L_0 is in correspondence with the measured radium content within limits of error. In this way we have found an average value for the rate of sedimentation during the period of time considered. The values thus found are of the order of 1 mm. in 1,000 years, in fair agreement with other methods of estimation. This method is, however, liable to errors, arising on one hand, as mentioned before, from a possible change in the rate of ionium sedimentation and, on the other, from the complication represented by the vertical migration of radium in the sediment.

A full report on these measurements and calculations will be published in the Reports of the Swedish Deep-Sea Expedition.

Viktor St. Kröll

Oceanografiska Institutet,
Göteborg.
Jan. 14.



Radium concentration in a red clay core from the Central Pacific Ocean at lat. N. 02° 23′, long. W. 173° 50′, depth of water 5,560 m. A manganese nodule with a concentration of $97{\cdot}1 \times 10^{-12}$ gm. radium/gm. sediment was found at a depth of 32 cm. in the sediment

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Ionium Determination in Deep-Sea Sediments

Measurements carried out in the Oceanographical Institute, Göteborg, on the radium content in deep-sea cores by H. Pettersson, Traude Bernert, V. Kröll[1] *et al.* showed the vertical distribution of radium to be highly complicated. We were therefore asked to develop a method for direct measurement of the ionium content in samples of sediment from the Swedish Deep-Sea Expedition.

Uranium-X_1 (thorium-234) is added to a solution of the sample as radio-tracer for ionium (thorium-230).

The solution (0·5 *N* hydrochloric acid) is passed through a column of ion exchanger ('Amberlite *IR*100'). Elution with 2 *N* hydrochloric acid removes most of the cations, including uranium and radium. A second elution with 0·5 *M* oxalic acid[2] releases the thorium isotopes together with polonium; the last-named element is removed by extraction with dithizone[3]. Oxalic acid is removed by calcination, and the nearly carrier-free thorium (ionium + uranium X_1) redissolved in the smallest possible volume of a complexing solution of citric buffer at *p*H 7[4]. The yield of ionium recovered is checked by counter-measurements of the β-activity of the uranium-X_1. The concentration of ionium is measured by the α-radiation detected with nuclear emulsion using the double-emulsion technique[5].

Assuming radioactive equilibrium between thorium and radio-thorium to prevail in the sample, the proportion of α-track 'stars' with five branches on the plates gives the concentration of thorium and permits the separation of thorium and ionium, since the latter gives only single α-tracks[6]. The method also permits the detection of possible residues of radium from the number of three- and four-branched stars. Measurements of the lengths of the tracks make it possible to detect impurities like uranium and polonium which give also single tracks.

The method was checked with a standard solution of ionium containing 10^{-11} gm. ionium/c.c., obtained by dissolving a sample of pitchblende and measuring the concentration of uranium in the solution. In this solution uranium was known to be in radioactive equilibrium with its descendants[7]. The concentration of ionium in this solution was of the same order as that in the uppermost layers of sediment examined.

The main difficulty lies in the preparation of uranium-X_1 of sufficient purity and in the elimination of radioactive contamination by the chemicals used and by the photographic emulsion.

The method enables us at present to measure a concentration of ionium between 10^{-9} and 10^{-10} gm./gm. to within 10 per cent, and to detect a concentration of 10^{-11} gm./gm. in a sample weighing 0·5 gm., a quantity which, by the use of micro-chemical methods, could be reduced to a few milligrams. An absolute quantity of ionium as low as 10^{-12} gm. contained in a volume of 10^{-3} c.c. can easily be measured by the photographic method.

Our main purpose has been to ascertain whether, in deep-sea sediments, there exists radioactive equilibrium between ionium and radium. For lack of a suitable method of determining ionium, it has hitherto not been possible to solve this problem. For this reason all conclusions regarding the vertical distribution in the sediment cores of ionium and subsequent inferences regarding the rate of sedimentation have so far had to be based on radium measurements and on the hypothesis that there is radioactive equilibrium between ionium and radium in the cores.

The samples we have worked on were taken from cores of deep-sea sediments raised in the Pacific Ocean by the Swedish Deep-Sea Expedition. Their radium content has been measured in Göteborg. The results so far obtained are too few to allow any general conclusions to be drawn, and the figures set out in the accompanying table should be considered as preliminary values, subject to revision after control measurements. With these reservations, they seem to lend support to the hypothesis of ionium precipitation, and they further indicate that the irregularities found in the radium curves may be due to a lack of radioactive equilibrium between ionium and radium.

Sample No.	Core No.	Depth in sediment (cm.)	Radium (10^{-12} gm./gm.)	Ionium (10^{-12} gm./gm.)	$R = \frac{\lambda_{Ra} N_{Ra}}{\lambda_{Io} N_{Io}}$
4	83	3·5– 4·5	27·9	14	1
5	83	31·5–32·5	46·4	10	2·3
11	86*B*	11·5–13	38	20	1
12	86*B*	16·5–17·5	52	13	2
13	86*B*	48 –49	19·1	$\ll 1$	$\gg 1$

We wish to thank the Oceanographical Institute of Göteborg, and in particular Prof. H. Pettersson, for support. We are indebted to Profs. F. G. Houtermans and G. P. S. Occhialini and to Dr. H. Rotschi for helpful suggestions, and to Mr. C. Waller (Ilford, Ltd.) for supplying specially purified emulsion.

N. Isaac
E. Picciotto

Centre de Physique Nucléaire,
l'Université libre de Bruxelles.
Jan. 14.

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An Interferometer Microscope for the Accurate Measurement of Optical Thickness

The methods developed by Barer[1] and Davies and Wilkins[2] for the measurement of the dry weights of cells involve the accurate measurement of the optical thickness of the cell at a number of points on its surface. In many cases, the optical thickness is quite a small fraction of a wave-length, so the measurement must be made with considerable accuracy; furthermore, in the case of a living cell, speed of measurement is essential.

In order to fulfil these conditions, a new type of interferometer microscope has been designed. The basic arrangement of the microscope is similar to that of Lebedeff[3], in which the specimen is enclosed between two birefringent plates together with a suitably oriented half-wave plate. Lebedeff's microscope, however, enabled only very thin plates to be used at high powers, resulting in a doubling of the image. To overcome this difficulty, a glass hemisphere is cemented to the upper plate to increase the working distance of the objective[4]. In this way, plates 5 mm. thick can be used with a 4-mm. objective, and the second image becomes so far out of focus that it disappears.

The system gives an image of the light source and an image of the source with the object superimposed, coincident and polarized mutually at right-angles. If viewed through an analyser at 45° to each plane of polarization, the two images interfere and the object is revealed by normal interference contrast. In order to effect the measurement, further modifications are introduced. A birefringent quarter-wave plate is placed above the objective, suitably oriented so that the image and reference beams are circularly polarized in opposite senses thereby. These two beams then combine to form a single plane-polarized beam,

with an orientation of polarization depending on the phase differences between the two beams. The plane of polarization may then be rotated by a rotatable half-wave plate with suitable scale. The phase-difference may be measured by rotating the plane of polarization to a fixed position and reading off from the scale the angle through which it has been turned.

In order to determine accurately when the plane of polarization has a given direction, a half-wave plate consisting of a sheet of 'Cellophane' is placed in the focal plane of the eyepiece. A system of small squares, arranged in chequer-board formation, is cut out of the half-wave plate, and the analyser is fixed, making an angle of 45° with the principal directions of the half-wave plate. Under these conditions, there is an intensity contrast between the cut-out squares and the rest of the field unless the plane of polarization is parallel to one of the principal directions of the half-wave plate. Hence, an accurate setting for the orientation of the plane of polarization is possible by adjusting for disappearance of each small square in turn.

Using mercury green light, it has been found possible under good conditions to repeat settings within ± 0·25°, which corresponds to ± 0·003 wave-lengths, as a complete rotation corresponds to four wave-lengths. The chequer-board formation of the squares facilitates the averaging of optical thickness over the cell.

J. Dyson

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston Court,
Aldermaston, Berkshire.
Feb. 9.

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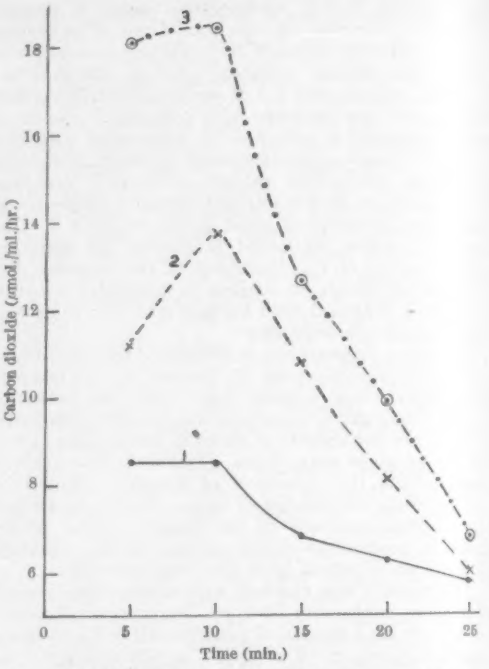
Hydrolysis of Anhydrides by Esterases

In recent investigations[1] the idea was expressed that tetraethyl pyrophosphate and related inhibitors of esterases are enzymatically split into a positive phosphonium ion and a negative residue, the former attaching itself to a nucleophilic group in the active surface of the enzyme. The irreversible combination of organic phosphates with esterases is thus analogous to the reaction of esters as substrates: here the acylinium ion is attached reversibly to the enzyme. The ease with which anhydride bonds are split was used for explaining the superiority of this type of inhibitor over trialkyl phosphates. However, since esters are the natural substrates of esterases, it can be expected that both types of compounds, esters as well as anhydrides, are attacked by the same enzyme, the latter at a faster rate. This was borne out by the following experiments.

(1) Carboxylic acid anhydrides are split both by acetylcholine esterase and by liver esterase. This cannot be demonstrated 'directly' by adding the substrate to the buffered enzyme solution, since spontaneous hydrolysis of such anhydrides in dilute aqueous media is very rapid. We have therefore developed a 'two-phase' technique by placing the substrate, dissolved in toluene, into the side bulb of a Warburg vessel. Upon adding the organic solution to the main vessel, an equilibrium between the two layers is established, thus supplying the aqueous phase continuously with small amounts of substrate. The accompanying graph shows that liver esterase increases the hydrolysis of propionic anhydride by about 100 per cent and the choline esterase by about 60 per cent.



Enzymatic hydrolysis of propionic anhydride. The anhydride was dissolved in toluene, 1 : 100; 0·2 ml. was added to the side bulb of each Warburg vessel. The main vessel contained 2·9 ml. of (1) bicarbonate buffer (control); (2) acetylcholine esterase, 1 : 2,500 (this preparation from electric organ, when diluted 1 : 40,000, hydrolysed 6 μmol./ml./hr., when acetylcholine, $3·3 \times 10^{-3}$ *M*, was used as standard substrate); (3) liver esterase, 1 : 60 (this enzyme from dog's liver, at a dilution of 1 : 100, produced 5·2 μmol. carbon dioxide/ml./hr., when diacetin, $4·1 \times 10^{-2}$ *M*, was used as standard substrate). Note that 2 mol. carbon dioxide is equivalent to 1 mol. propionic anhydride

(2) By using the dilution technique, we have been able to demonstrate that triethyl phosphate is an irreversible inhibitor of acetylcholine esterase, but the concentrations required for a given degree of inhibition are 100–200 times higher than with tetraethyl pyrophosphate (see table).

(3) On the basis of these results, it can be expected that a mixed phosphoric – carboxylic anhydride will also be split by esterases, but the direction of the

Irreversible Inhibition of Acetylcholine Esterase by Triethyl Phosphate

The enzyme, 0·2 ml., was incubated with 1·0 ml. of a $7·2 \times 10^{-4}$ *M* solution of the inhibitor in bicarbonate buffer (0·1 *M*). After 30 min. the mixture was diluted 250 times and its hydrolytic activity measured by the Warburg method. Final dilution of the enzyme 1 : 1,500; final concentration of the inhibitor $2·4 \times 10^{-6}$ *M*. A control was run by diluting the inhibitor first and then incubating with the enzyme. The substrate was acetylcholine, $3·3 \times 10^{-2}$ *M*

	Activity (μmol. hydrolysed/ml./hr.)	% Inhibition
1. Enzyme alone, 1 : 1,500	5·5	
2. Enzyme + diluted inhibitor	3·6	35
3. Enzyme + concentrated inhibitor	nil	100

hydrolysis is not predictable. If the C—O bond is broken, the mixed anhydride will serve as substrate, whereas attack at the P—O bond will lead to inhibition. We have found that dibenzyl acetyl phosphate is an irreversible inhibitor of choline esterase. Since this anhydride is split by water very rapidly, the inhibitory effect was demonstrated by adding 0·01 ml. of the undiluted inhibitor to 0·1 ml. of the buffered enzyme. After 5 min. at room temperature, the mixture was diluted thirty times and the remaining activity of the enzyme compared with an untreated control. Under these conditions our derivative of acetyl phosphate produced complete inactivation of the esterase, whereas the control hydrolysed 6 μmol. of acetylcholine/ml./hr. Treatment of the enzyme with a 1 : 30 dilution of the anhydride in buffer gave no inhibition because of the rapid spontaneous hydrolysis of the inhibitor.

A detailed account of these experiments will be published elsewhere. We wish to thank Mr. J. Blank for the preparation of dibenzyl acetyl phosphate.

Felix Bergmann
Menachem Wurzel
Arela Shimoni

Department of Pharmacology,
Hadassah Medical School,
Hebrew University,
Jerusalem.
Nov. 19.

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Enzymatic Transoximation

It has been recently shown[1] that oximes are enzymatically converted into amino-compounds. I have now demonstrated an enzyme which catalyses the transoximation.

The enzyme was prepared from silkworms. 2 gm. of digestive organ-free tissues of fifth instar larvæ was ground and centrifuged twice after adding water. The residue was mixed with 3 ml. of 0·01 *M* pyruvic acid oxime, 3 ml. of 0·01 *M* acetaldehyde and 3 ml. of 0·01 *M* acetone and then diluted with water or 0·015 *M* buffer to 30 ml. The mixture was put in a 100-ml. Erlenmeyer flask, covered with toluol and kept at 35° C. for 15 hr. After reaction, the mixture was distilled *in vacuo*, and the total amount of acetaldoxime and acetoxime in the distillate was determined colorimetrically. In the control, the enzyme preparation was used after heating at 100° C. for 10 min.

Experiments indicated that the enzymatic activity was reduced to half by heating at 60° C. for 10 min. The optimum *p*H of enzyme action was about 5·6 and the optimum temperature 37° C. Under the experimental conditions described above, about 10 μgm. of oxime-nitrogen was transferred, and no free hydroxylamine or nitrous acid was detected in the reaction mixture. I suggest the name 'transoximase' for the enzyme.

Kazuo Yamafuji

Agricultural Chemistry Institute,
Kyushu University,
Fukuoka, Japan.
Oct. 24.

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Active Absorption of Glucose from the Intestine

Glucose disappeared rapidly from the lumen of an isolated loop of rat intestine, immersed in tyrode at 37° C. and aerated by a mixture of oxygen and 5 per cent carbon dioxide. This occurred even when the solutions (tyrode containing 200–800 mgm. per cent glucose) within the loop and surrounding the loop were identical, so that no concentration gradient of glucose existed between the inner and outer solution. The rate of uptake of glucose, during the first 15–30 min., was of the same order of magnitude as that found during resorption *in vivo* from similar solutions. With other sugars, the uptake was related to their rate of resorption in the intact animal. Phlorrhizin inhibited absorption of glucose *in vitro* as well as *in vivo*. It therefore seemed probable that we were dealing with 'active absorption' when using such a preparation.

Though glucose disappeared from the lumen, glucose as such was not transferred across the intestinal wall, and the outer fluid showed no increased glucose content. When a similar experiment was carried out with radioactive glucose in the inner solution, a radioactive substance appeared in the outer fluid ; 30–60 per cent of the radioactivity which had disappeared from the inner solution could thus be recovered. The recovery increased with time of incubation up to one hour. The radioactive substance is not identical with glucose ; it is non-reducing and is not fermented by baker's yeast. It is not converted into glucose by acid hydrolysis, and so far has not been identified with any known intermediate of glucose dissimilation. Much of the glucose which had disappeared was retained in the lumen as a substance having characteristics similar to those of the substance appearing in the outer solution.

It was of interest to ascertain whether the conversion of glucose to a metabolite, in its passage across the intestinal wall, is a general phenomenon or is associated with the conditions prevailing in these *in vitro* experiments. It is generally believed that glucose absorbed from low concentrations (that is, during active absorption) is transferred to the portal vein as glucose. However, the evidence provided by the literature was found to be both scanty and unconvincing. Most papers dealt only with the fate of glucose in the intestinal lumen, but had very little to say about its appearance on the other side of the intestinal barrier.

In order to test this, glucose concentrations in the portal vein and in the artery were compared during resorption of glucose from a 400 mgm. per cent solution. In a representative experiment, 18 mgm. of glucose disappeared during 12 min. With a blood flow of 4 ml./min. (calculated from data of Birnie and Grayson[1]), the glucose concentration in the vena porta should have exceeded that in the artery by 37 mgm. per cent, if it was glucose which was transported by the vena porta. However, the glucose concentration in the vena porta was found to be even lower than in the arterial blood.

Further proof that no additional glucose as such appears in the vena porta during glucose absorption was then sought by perfusing the intestine *in situ* with blood of known composition. When a 400 mgm. per cent glucose solution was introduced into the loop of a perfused intestine, 17·2 mgm. glucose disappeared in 12 min. but no additional glucose could be found in the perfusion fluid. With radioactive

glucose in the lumen, a substance could be demonstrated in the perfusion fluid similar to that found in the outer fluid in our *in vitro* experiments (making up 35 per cent of the glucose which disappeared).

It might be claimed that with low glucose concentrations a considerable part of the glucose is utilized by the intestine. However, measurement of oxygen consumption, both *in vivo* and *in vitro*, revealed that less than 10 per cent of the glucose taken up is burned to carbon dioxide. It seems that most of the absorbed glucose is transferred in the form of a metabolite through the portal system and is reconverted into glucose in some other organ, presumably in the liver. The active translocation of glucose from the intestinal lumen into the blood stream would thus involve the participation of both the intestine and the liver.

Experiments are being conducted to test this assumption.

S. Hestrin-Lerner
B. Shapiro
Laboratory for Pathological Physiology,
Hebrew University,
Jerusalem.
Oct. 22.

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Distribution of Substance *P* in the Central and Peripheral Nervous System

Substance *P* is a biologically active polypeptide found in extracts of brain and intestine[1,2]. It causes a transient fall of the blood pressure and stimulation of smooth muscle even in the presence of atropine and antihistamine drugs. Purified preparations exert biological effects even in concentrations of 1 μgm. per ml. The present communication deals with its distribution in the nervous system.

Extracts, obtained from the dog, were prepared by boiling the tissue in water at *p*H 4, and tested on the isolated guinea pig ileum in the presence of 1 : 2,500,000 atropine and 1 : 2,500,000 of antihistamine (Lergitin). The activity of the extracts was compared to a standard of a partially purified preparation of substance *P*, obtained from horse intestine by precipitation with ammonium sulphate[3]. The specificity of the active factor was proved by precipitation in some cases with ammonium sulphate and inactivation with chymotrypsin.

(1) *Central nervous system.* The highest values were found in the grey matter, which agrees with the results of Euler and Gaddum[1]. This may suggest that the substance is concentrated in the cell bodies. In the cerebellum, however, with its high content of cells, the amount of substance *P* is low. Its activity of the different parts of the central nervous system runs almost parallel to the acetylcholine content[4], except in the extracts of the hypothalamus, which show the highest concentration of substance *P* in the brain.

Table 1. Distribution of Substance *P* in the Central Nervous System

Tissue	Units of subst. *P*/gm. tissue
Medulla spinalis	35
Pons	45
Cerebellum	15
Tegmentum	75
Hypothalamus	180
Tractus opticus	50
Thalamus	85
Basal ganglia	130
Corpus callosum	8
Bulbus et tractus olfactorius	9
Hemisphere	20
Plexus choroidæus	1

(2) *Peripheral nervous system.* Substance *P* activity is found in extracts of all kind of nerves and ganglia. The values obtained, however, are generally lower than those found in the central nervous system. The dorsal roots, the preganglionic sympathetic fibres and the vagus seem to be especially rich in substance *P*, whereas motor nerves such as the phrenic have a low content.

Table 2. Distribution of Substance *P* in the Peripheral Nervous System

Tissue	Units of subst. *P*/gm. tissue
N. opticus	7
N. saphenus	13
Radices dorsales, reg. lumbalis	45
N. phrenicus	5
Radices ventrales, reg. lumbalis	25
N. ischiadicus	10
N. vagus	25
Truncus sympaticus cervicalis	40
N. splanchnicus	15
N. lienalis	10
Ganglion stellare	20
Ganglion nodosum	15

A full account of this work will be published in *Acta Physiol. Scand.*, Suppl. 105.

Bengt Pernow
Department of Physiology,
Faculty of Medicine
(Karolinska Institutet),
Stockholm. Nov. 27.

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A New Synthesis of some Derivatives of 4,4′-Stilbenediol

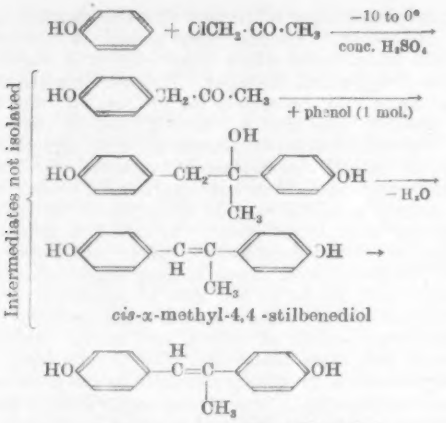
Syntheses of α-alkyl- or α,α′-dialkyl-4,4′-stilbenediols and of their derivatives, several of which exhibit remarkable œstrogenic activity, have so far mostly been by demethylation of the corresponding dimethyl ethers, and have invariably involved several stages[1,2]. A direct synthesis in one step, of *trans*-α-methyl-4,4′-stilbenediol (and some of its dialkyl ethers) from phenol (or its corresponding ether) and chloroacetone, has now been accomplished.

The condensation of chloroacetone with phenol in presence of concentrated hydrochloric acid at 100° has been reported to yield 2,2,3-tris(*p*-hydroxyphenyl)propane[3]. We have found that in presence of concentrated sulphuric acid at − 10° to 0°, the above reactants give a nearly 75 per cent yield of *trans*-α-methyl-4,4′-stilbenediol (earlier synthesized by Dodds and his collaborators[2]) (melting point 183–184°). The melting points of some ethers and esters of this substance, prepared by the usual methods, are shown in the accompanying table.

Ether or ester of *trans*-α-methyl-4,4′-stilbenediol	Melting point
Dimethyl ether*	124°
Diethyl ether	105–107°
Dipropyl ether	107–108°
Diallyl ether	94–95°
Diacetate*	124°
Dipropionate	107–108°

* Previously described by Dodds *et al.* (ref. 2).

The above condensation, yielding *trans*-α-methyl-4,4′-stilbenediol, probably proceeds according to the following route :



The extreme activity of the chlorine atom of the chloroacetone molecule by reason of its vicinity to the carbonyl group, and the reactivity of the hydrogen atom *para* to the hydroxyl group in the phenol molecule, suggested a Friedel–Crafts type of reaction as the first step.

The above reaction would appear to be generally applicable to ketones of the formula R—CO—CHClR', where R is a lower alkyl radical and R' is hydrogen or a lower alkyl radical, and any simple aromatic compound containing a suitably activated available nuclear hydrogen atom. Thus, the dimethyl and diethyl ethers of *trans*-α-methyl-4,4′-stilbenediol have also been obtained, in very good yields, by condensing chloroacetone with anisole and phenetole respectively in presence of concentrated sulphuric acid.

In these reactions, the *cis* compounds seem to be formed first, and are probably converted to their *trans* isomers on heating in solution in solvents like alcohol or aqueous alcohol; thus in the condensation of anisole and phenetole with chloroacetone, the crude semi-solid reaction product, after treatment with water at 0°, yielded only a viscous oil (presumably the *cis* compound) when recrystallization from alcohol was attempted; but when an alcoholic solution of this oily product was refluxed for a few hours and then cooled, the *trans* form of the corresponding dialkyl ether of α-methyl-4,4′-stilbenediol crystallized out.

A fuller account will be published in due course. We are grateful to several colleagues for the benefit of discussion. One of us (P. M. B.) is indebted to the National Institute of Sciences of India for the award of a research fellowship.

P. M. Bhargava
S. Husain Zaheer

Central Laboratories for
Scientific and Industrial Research,
Hyderabad, Deccan.
Sept. 12.

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Carbohydrate Metabolism in Protozoa and Metal-binding Substances

The effect of cyanide on fermentation processes of living cells, which is on the whole much smaller than that on respiration, has been interpreted in the past as due to the interception by cyanide of intermediary products of fermentation, rather than to complex formation with heavy-metal catalysts; as pointed out again only recently, "no enzyme of fermentation is known to require the addition of a heavy metal except the aldolase of yeast"[1]. That not all living cells conform with this view has already been indicated by our previous work on the metabolism of certain Protozoa, and in particular by the finding that the anaerobic fermentation of glucose by the flagellate *Trypanosoma lewisi* is inhibited 50 per cent by 0·007 M cyanide and also by such metal-binding substances as 2 : 2′-dipyridyl and 8-hydroxyquinoline[2]; on the other hand, the same metal-binding substances have been shown to have a small but definite stimulating effect on intracellular glycogen fermentation in the ciliate *Tetrahymena pyriformis*[3]. These effects have now been investigated further.

Under aerobic conditions at 37° C., washed suspensions of *Trypanosoma lewisi* in the absence of extracellular nutrient respire with a q_{O_2} of about 40 and a respiratory quotient of 0·80 for a period of 1–2 hr. During this time, the flagellate shows a small degree of motility; but, within 5–10 min. of the addition of glucose, motility increases considerably, and the q_{O_2} rises to about 600, with a respiratory quotient of almost unity. When, however, the flagellate is incubated for longer periods of time in the absence of substrate, the endogenous respiration and motility gradually fall, and the ability to respond to added glucose is lost, death of the trypanosomes soon taking place. The respiration of the trypanosome in the presence of glucose is not markedly influenced by 0·001 M 2 : 2′-dipyridyl, there being only a 10 per cent inhibition of respiration and scarcely any effect on motility over the first hour, with a somewhat greater inhibition of respiration and motility after 2–3 hr.; a similar effect is produced by 8-hydroxyquinoline. If, however, substrate-free trypanosomes are incubated with 0·0003 M 2 : 2′-dipyridyl, their ability to respond to added glucose is quickly lost; after 30 min. incubation, the recovery of respiration and motility is slow and incomplete, while after 90 min. the trypanosomes become immotile, and will not respond to added glucose, although, in the absence of inhibitor, normal motility is restored within 15 min. of the addition of glucose.

Under anaerobic conditions, the effects of 2 : 2′-dipyridyl and 8-hydroxyquinoline on carbon dioxide production by the trypanosomes in the presence of glucose and a carbon dioxide – bicarbonate buffer are much greater. When added to actively fermenting trypanosomes, 0·0003 M 2 : 2′-dipyridyl reduces carbon dioxide output by 65–75 per cent over a period of 45 min., metabolism and motility having ceased completely by this time. On addition of the reducer sodium dithionite to such a suspension, a pale pink colour is produced, indicating the formation of a ferrous iron–dipyridyl complex. 0·0001 M 2 : 2′-Dipyridyl is almost as effective, while 8-hydroxyquinoline produces a slightly quicker inhibition. These metal-binding substances are more effective when added to substrate-free trypanosomes at the same time as glucose, rather than to actively ferment-

ing cells. The effect of 2 : 2′-dipyridyl on fermentation is irreversible.

During studies of the intermediary metabolism of *Trypanosoma lewisi*, using homogenates prepared by shaking an aqueous suspension of cells with glass beads, the effect of 2 : 2′-dipyridyl on aldolase activity was investigated. The disappearance of fructose-1 : 6-diphosphate and the production of alkali-labile phosphate were followed in a system containing cell homogenate, incubated at 37° C. in the presence and in the absence of 0·06 *M* potassium cyanide. At *p*H 7·0 or 6·4 in carbon dioxide – bicarbonate or acetate – veronal buffers, the reaction was scarcely affected by 0·001 *M* 2 : 2′-dipyridyl, while 0·005 *M* 2 : 2′-dipyridyl produced only a 33 per cent inhibition of aldolase activity. This result is quantitatively similar to that obtained with the ciliate *Tetrahymena pyriformis* (GL), an organism the respiration of which is insensitive to 2 : 2′-dipyridyl, and the fermentation of which is slightly stimulated by this substance[2].

It has recently been reported that aldolase activity in homogenates of the closely related flagellate *Trypanosoma cruzi* is not affected by 2 : 2′-dipyridyl; but no mention was made of the effect of this substance on the metabolism of intact cells[4]. The present results with *Trypanosoma lewisi* suggest that, although aldolase activity is probably independent of the presence of a heavy metal ion, such an ion, very probably ferrous iron, is involved at some stage in the glucose fermentation process. Inhibitions produced by 2 : 2′-dipyridyl are not prevented by the presence of hæmoglobin, and neither respiration nor fermentation is influenced by 0·0003 *M* 4 : 4′-dipyridyl; this indicates that if ferrous iron participates in fermentation, it is involved as the free ion, and not bound as a hæm compound. Under aerobic conditions, iron would be mainly in the ferric condition, and therefore not removed by 2 : 2′-dipyridyl; but under anaerobic conditions it would be reduced to the ferrous state, and could be quickly removed by chelation with 2 : 2′-dipyridyl.

I should like to thank Prof. D. Keilin and Dr. T. Mann for helpful discussions during the course of this work, and the Medical Research Council for a research studentship.

J. F. Ryley

Molteno Institute,
Cambridge*.
Sept. 25.

* Present address: Imperial Chemical (Pharmaceuticals), Ltd., Biological Laboratories, Morley, Wilmslow, Manchester.

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Nature of Cold Agglutinin Linkage

If sera containing auto-agglutinins ('non-specific cold agglutinins') are repeatedly absorbed in the cold with *O* cells, one of three results may be obtained: (1) activity against *A* and *B* cells may cease; this is the only result reported by numerous earlier workers; (2) activity against *A* and *B* cells may persist to a greater or lesser extent; subsequent absorption with *A* cells may leave some residual anti-*B* activity[1]; (3) activity against *A* and *B* cells may be enhanced[2].

These results support the view that auto-agglutinins are 'non-specific', because they consist of multiple specific components which may exhibit a varying degree of agglutinin linkage[3]. The multiple specific components may be anti-*O* (or *H*), anti-*A*, anti-*B*, and possibly also anti-A_1, anti-*M*, anti-*N*, anti-*P*, etc. The combination of non-specific cold agglutinins with an anti-*M* 'iso-agglutinin' reported by Macfarlane[7] may have been auto-agglutinins containing a relatively powerful anti-*M* component. It is not surprising that Henningsen[8], "by using a sensitive technique", could demonstrate anti-*P* antibodies in most *P*-negative sera. Some of these agglutinin components may figure in the lists of numerous antibodies occasionally detected in a single serum[9].

The enhancement of anti-*A* and anti-*B* activity in some sera after absorption with *O* cells may be of importance in providing a pointer to the structure of auto-agglutinins. The cold auto-agglutinins present in almost all sera are believed to be of heterogenetic bacterial origin[9]. These stimuli are continuous, minimal, and of varying antigenicity. It is not inconceivable that certain antibody receptors are first formed and followed by other more superficial receptors. Suppose anti-*A* and anti-*B* receptors are laid down in the beginning, and later a relatively large number of anti-*O* receptors are laid down. It would then be easy to visualize how the absorption of the anti-*O* receptors would unmask the anti-*A* or anti-*B* receptors.

This view is not inconsistent with Dodd's concept[4] of iso-agglutinin linkage, and might also account for the phenomenon of Hooker and Anderson[6]. These workers noted that, by absorbing certain immune rabbit anti-*B* sera with *O* cells, the sera developed the ability to act on *A* cells as well.

It is considered that this concept may also be of value in the elucidation of the true structure of antibodies in general.

G. W. G. Bird

Blood Transfusion Department,
Armed Forces Medical College,
Poona.
Aug. 21.

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Short-Term Carbon Dioxide Fixation in Mouse Liver

In a previous report[1], there were presented findings which were unexpected if the entire polycarboxylic acid cycle were involved in carbon dioxide fixation by animals. At 5 and 15 min. after the injection of radioactive sodium bicarbonate ($NaH^{14}CO_3$) (obtained as $Ba^{14}CO_3$ from the Atomic Energy Commission, Oak Ridge, Tennessee) there appeared to be a more direct path of carbon to succinate than that previously postulated. In addition, the labelling in such acids as α-ketoglutarate, citrate and aconitate was not measurable. It was thought desirable to

examine the path of carbon dioxide employing paper chromatography, because by this technique compounds retained by the silica gel (used in previous studies) which escaped examination would become detectable.

The active bicarbonate was injected intraperitoneally into mice weighing 20 gm. and the animals were sacrificed 3 min. later. Extracts were prepared by homogenizing the liver in 80 per cent ethanol, centrifuging and removing the supernatant. This solution was reduced in volume to 0·7 ml. 25 μl. was added in 1-μl. quantities to Whatman paper (No. 1, 14 in. × 16 in.) and chromatographed in glass cylinders. Phenol–water (4–1 v/v) and butanol–propionic acid – water[2] were the developing solvents used for the two-dimensional ascending chromatography[3]. After development, the paper was air-dried at 20° C. and placed over X-ray film for two weeks in a dark room.

In order to identify the darkened spots the solutes were chemically located on the paper, and thereby the radioactive spots on the film were described by super-position. Amino-acids were detected by the use of ninhydrin, and, when each amino-acid having activity was rechromatographed with the corresponding inert amino-acid, a single spot was obtained for the mixture in each case. Urea was identified with the phenol-chlorox reagent[3] and it was rechromatographed similarly. Since the quantities of organic acids were too small to be detected with the use of *p*H indicators, their distributions between 0·1 *N* hydrochloric acid in ether were studied, following extraction from the paper. Naturally occurring malic, oxalacetic and succinic acids showed distribution coefficients of 0·17, 0·045 and 0·012 respectively, as compared to 0·16, 0·043 and 0·15 for the authentic corresponding acids. Glucose was identified by the benzidine–acetic acid–ethanol reagent[4], and its position was confirmed by rechromatographing with reagent glucose. Since the distribution coefficients of succinate deviated by more than 10 per cent from the reagent value, the liver extract was chromatographed on silica gel[5], and the chromatographic zone assigned to succinate was assayed for activity.

Our results show, as previously, that the labelling in aconitic, fumaric and α-ketoglutaric acids is not detectable. The extent of incorporation of the tracer into succinate, oxalacetate and malate indicates, at least, that the total activity of these acids is greater than that of the other acids in the cycle. The relative concentrations[6] of these acids alone could not account for these results. This labelling of succinate and the absence of labelling of the other acids of the polycarboxylic acid cycle would seem to indicate that the cycle is not involved in a way that would be expected. Moreover, the lack of detectable activity in fumarate, the chemical concentration of which is greater than succinate[6], rules out the possibility that the oxalacetate served as a precursor of succinate by way of a reversed dicarboxylic acid cycle. The presence of the label to a small degree in glutamic acid but its absence in α-ketoglutarate can be explained by the higher concentration of the former in the liver. The most active compounds formed were glucose, urea, succinate, oxalacetate and malate. The appearance of the label in a large number of compounds suggests that the results for these short-term periods of carbon dioxide fixation *in vivo* cannot be accounted for by non-equilibration, and that the incorporation of the carbon-14 dioxide proceeds rapidly.

This investigation was supported in part by a grant from the Damon Runyon Memorial Fund.

LEMUELL C. LEEPER
FELIX FRIEDBERG
LAWRENCE M. MARSHALL

Department of Biochemistry,
School of Medicine,
Howard University,
Washington, D.C.
Sept. 30.

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Influence of Ovarian Hormones on Uterine Infection

Willett *et al.*[1] and Brock and Rowson[2] reported that pyometra frequently followed the insemination of cows when in the luteal phase of the œstrous cycle; but no definite reason for this occurrence was forthcoming. The present communication gives the results of experiments carried out on cows at various stages of the œstrous cycle and also on cows that had been ovariectomized.

A standard technique was adopted throughout the experiments, whereby the cervices of all animals were swabbed in the mid-cervical region for bacteriological culture using a sterile sheathed swab and sterile speculum. Immediately afterwards, the cows were inseminated by passing a normal sterile insemination pipette through the cervix and into the body of the uterus where the inseminated material was deposited. The material injected was either buffered semen known to be infected or cultures of *Corynebacterium pyogenes* isolated from bull semen. Two days after insemination, all cows were slaughtered and the reproductive organs removed for bacteriological examination.

The experiments were divided into three parts: (1) bacteriological examination of the uterus both before and after insemination with infected material in the luteal and follicular phases of the œstrous cycle; (2) bacteriological examination of the uterus after insemination following the injection of stilbœstrol or progesterone into ovariectomized cows; (3) studies of the effect on bacteria of penicillin, streptomycin and sulphanilamide added to infected material inseminated during the luteal phase.

The work proved quite conclusively that when infected material was injected into the uterus during the luteal phase of the cycle, pyometritis invariably resulted. On the other hand, all cows which were inseminated during œstrus had sterile uteri on slaughter two days later.

It was found that these phenomena could readily be reproduced in ovariectomized cows by the administration either of progesterone or stilbœstrol. In some cases pure cultures of *Corynebacterium pyogenes* were used instead of infected semen; yet in the animals given stilbœstrol, the uteri were sterile two days later. In ovariectomized control cows not receiving exogenous hormones, a sterile pyometritis resulted.

The results on control animals indicated that this phenomenon is due more to a stimulating effect of progesterone rather than to an inhibiting effect of œstrogen, but that the latter, in sufficient doses, will tend to overcome the effect of the former.

In the third experiment it was found that although the antibiotics and sulphanilamide prevented severe pyometritis and gave sterile uteri at slaughter, a certain amount of cellular debris had collected in the uterus giving the appearance of a mild pyometritis.

These results are of particular interest because they indicate quite clearly the tremendous bactericidal properties of the uterus during œstrus. They may explain why cows sometimes recover spontaneously from *Vibrio fœtus* and trichomonad infections after a number of heat periods without re-infective coitus. They may also indicate why the bull does not recover spontaneously from infections of *Vibrio fœtus* and trichomoniasis, for the bull normally secretes testosterone from the testis, which has a similar effect to progesterone. If testosterone has a similar effect in the bull to progesterone in the cow, then continuous testosterone production by the testis would make spontaneous recovery from genital infection of the bull unlikely. Experiments now planned are designed to show whether or not it is possible to treat such infected bulls successfully with exogenous œstrogen.

The possibility of controlling by the use of œstrogens the infections which follow abortion or parturition in the human might also be worth investigation.

The experiments described here form part of the work being carried out by the Agricultural Research Council Unit of Animal Reproduction at Cambridge, and we wish to thank the Ministry of Food for the loan of the cows, Dr. John Hammond for advice and encouragement, and the staff of the Animal Research Station and Public Health Laboratory for their continuous help.

L. E. Rowson
G. E. Lamming

Agricultural Research Council
Unit of Animal Reproduction,
Huntingdon Road,
Cambridge.

R. M. Fry

Public Health Laboratory,
Tennis Court Road,
Cambridge.

Oct. 24.

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Mucin Secretion in the Ewe's Oviduct

As part of a study on the reproductive organs of the female sheep, histological and histochemical investigations were undertaken on the oviducts of thirty ewes to determine whether the epithelial cells exhibited secretory activity and, if so, to establish the nature of the secretion.

In this investigation it was found that material positive to Schiff's periodic acid[1] was secreted by the non-ciliated epithelial cells during pro-œstrus and œstrus. In pro-œstrus the secretory globules extended on each side of the nucleus towards the proximal part of the cell, whereas in œstrus the globules were confined to the distal portion. Secretion was found in the lumen during œstrus and met-œstrus but not during di-œstrus or pro-œstrus. Positive reaction was obtained after treatment with saliva, showing that the secreted material was not glycogen. This is at variance with the findings of earlier workers using the human oviduct. A positive reaction was obtained also after hyaluronidase, which excludes the presence of hyaluronic acid. The material did not exhibit metachromasia on staining with toluidin blue or celestin blue; and accordingly it is not an acid mucopolysaccharide. Again, a positive reaction with the periodic acid test was obtained after the methanol and chloroform test[2], thus eliminating the presence of glycolipid. In the light of these staining reactions, it can be assumed that the material was mucoprotein or "neutral mucopolysaccharide"[3].

The secretory cells were most numerous in the ampulla, and therefore the secretion was most abundant in this situation. The number of secretory cells was greatly reduced in the isthmus, and none was present in the vicinity of the oviduct–uterine junction.

A detailed account of this work will be published elsewhere.

R. Hadek

Department of Histology and Embryology,
University of Glasgow Veterinary School,
83 Buccleuch Street,
Glasgow, C.3.

Nov. 15.

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Paper Chromatography of Œstrogens

The Burton, Zaffaroni and Keutman[1] method for the paper chromatographic analysis of the adrenal cortical steroids has been found to be suitable for the non-steroid œstrogens of the hexœstrol series (hexœstrol, stilbœstrol, dienœstrol, trienœstrol[2]) and ethinyl œstradiol. It can also be used for the natural œstrogens (private communication from H. Grundy). Development is carried out using the toluene – propylene glycol system, and the detecting reagent, a mixture of 1 per cent ferric chloride and 1 per cent potassium ferricyanide as used by Barton, Evans and Gardner[3], gave a blue spot with less than 2 μgm./sq. cm. of the run synthetic œstrogen. In addition, stilbœstrol, dienœstrol, trienœstrol but not hexœstrol gave a strong absorption at 2300 A., and dienœstrol a blue and trienœstrol a green fluorescence at 3600 A.

The presence of trienœstrol in the urine, fæces, but not blood extracts of animals injected with the œstrogen, has been demonstrated using this paper chromatographic method, and the amount estimated by the modified Allen Doisy[4] bioassay technique. Trienœstrol, when added to blood, could be easily detected. Similarly, in animals injected with ethinyl œstradiol, the unchanged œstrogen, but no œstrone or β-œstradiol, could be detected in the fæces.

This method of chromatography is, however, not very suitable for detecting œstriol in urine or fæces, as other very slow-moving chromogenic compounds interfere. A fuller account of these results as well as those obtained from the injection of other œstrogens will be published elsewhere.

ŒSTROGENS CHROMATOGRAPHED IN TOLUENE–PROPYLENE GLYCOL IN ORDER OF DECREASING MOVEMENT

Compounds	Movement ratios
Œstrone— 11-Deoxycorticosterone	0·40
Ethinyl œstradiol— 11-Deoxy-17-hydroxycorticosterone	0·73
17-β-Œstradiol — 11-Deoxy-17-hydroxycorticosterone	0·55
Hexœstrol — 11-Dehydro-17-hydroxycorticosterone	1·1
Stilbœstrol — 11-Dehydro-17-hydroxycorticosterone	
Dienœstrol — 11-Dehydro-17-hydroxycorticosterone	
Trienœstrol — 11-Dehydro-17-hydroxycorticosterone	0·81
Œstriol	Extremely slow

I wish to thank Prof. E. C. Dodds for having made this work possible, and Mr. W. Lawson for his interest in the work and for supplying the œstrogens.

P. H. JELLINEK

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.
Nov. 25.

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Iodination of Keratin

FOR the purposes of another investigation, it has been found necessary to devise a method of iodinating the tyrosine side-chains of keratin exclusively and completely. With aqueous solutions of iodine (0·1 *N*), no more than 75 per cent of the tyrosine of wool was iodinated under the best conditions used (64 hr. at 22·2° C. and *p*H 9). It has, however, been found that almost complete conversion into 3 : 5-di-iodo-tyrosine is obtained by treating wool (0·421 gm.) with a 0·78 *N* solution of iodine in absolute alcohol (50 c.c.) for 72 hr. at 25° C.

The tyrosine contents of the treated and untreated wools were determined by the method of Block and Bolling[1], and were found to be 0·214 and 4·77 per cent, respectively. If 3 : 5-di-iodo-tyrosine is the only reaction product, the fall in tyrosine content corresponds almost exactly to the amount of combined iodine (6·45 per cent). In agreement with this result, similar experiments with amino-acids showed that whereas tyrosine is readily iodinated under the above conditions, histidine reacts only to a negligible extent and tryptophane and proline not at all. Partial iodination of tyrosine gives more mono-iodo-tyrosine than di-iodo-tyrosine, contrary to Li's deduction[2] that tyrosine is slowly iodinated to mono-iodo-tyrosine, which then reacts instantaneously to give di-iodo-tyrosine.

H. R. RICHARDS
J. B. SPEAKMAN

Textile Chemistry Laboratory,
Department of Textile Industries,
University, Leeds 2.
Nov. 24.

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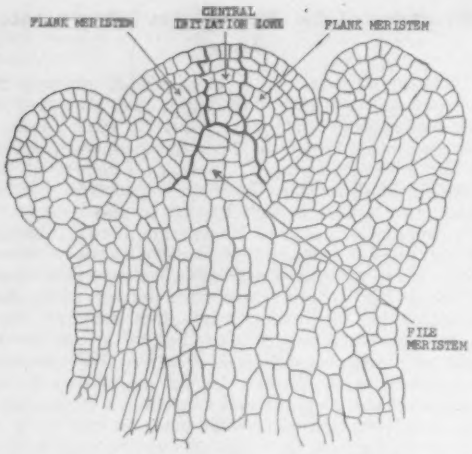
Structure of the Angiosperm Inflorescence Apex

ALTHOUGH there is a considerable amount of information available concerning the structure of the angiosperm shoot apex, relatively little research has been carried out into the anatomical construction of the inflorescence apex. Grégoire's theory of the histological differences between vegetative and reproductive apices is well known to the student of developmental anatomy. He was unable to find tunica and corpus zones in the reproductive apices he examined. However, this observation has been challenged by recent workers, and these zones are now recognized in both types of growing-point. Few attempts have been made to interpret reproductive apices in the light of the cyto-histological zonation now generally recognized to be present in the vegetative apex[1]. Philipson[2] and Popham and Chan[3] have investigated the zonal changes that take place in the apex in the transition from the vegetative to the reproductive state in a number of dicotyledonous plants. It is claimed that, although central initiation, flank meristem and file meristem zones can be identified in the early inflorescence primordium, the central initiation zone later disappears and is replaced by flank meristem.

Anatomical investigations have been carried out by us on certain members of the Cruciferæ where the main inflorescence definitely terminates the leafy axis. Of the plants examined, *Arabidopsis thaliana* (L.) Heynh. proved the most instructive because it was possible to fix material grown under carefully controlled photoperiodic treatment, and thus apices in all stages from the purely vegetative to the flowering condition were obtained.

The first obvious change in the transition is an increased rate of cell division in the file meristem zone to convert the slightly convex vegetative apex into a large dome-shaped inflorescence primordium, down the sides of which extend the flank meristem. In this flank meristem are initiated first the cauline leaf primordia and then the flower primordia.

The cell-outline drawing shown is of a median longitudinal section through the *Arabidopsis* inflorescence apex with two flower primordia cut obliquely. The three main zones of the apex are labelled. The cells of the central initiation zone, as usual, stain less densely with protoplasmic stains than the surrounding flank meristem where mitotic divisions are to be observed frequently. This apex is more convex than the vegetative one, and file meristem cells, cut off from the lowermost cells of the central initiation zone, soon elongate in a plane parallel to the longitudinal axis of the inflorescence and undergo repeated transverse and longitudinal divisions. In the vegetative apex, the file meristem is poorly developed. Apart from these differences, the *Arabidopsis* apex producing flower primordia is essentially the same as that producing leaf primordia. Both differences are obviously related to growth processes. It has been stated[1] that the poor development of file meristem in the *Arabidopsis* vegetative apex is connected with the rosette habit of the plant. The active development of file meristem in the inflorescence apex, now under consideration, is obviously related to the active growth in a vertical direction of the inflorescence axis. The difference in shape of the two types of apex seems to be the result of the production of different types of lateral member. It has been observed, from an examination of numerous



Cell outline drawing of median longitudinal section of the inflorescence apex of *Arabidopsis*. (× 200)

series of sections, that a greater expansion of flank meristem needs to be reconstituted by the central initiation zone of the inflorescence apex before a flower primordium is initiated than in the vegetative apex before the initiation of a leaf primordium. As this greater expansion of flank meristem is being produced, the file meristem cells are undergoing active divisions to produce growth in length of the axis. A combination of these two growth processes will obviously produce a very convex apex.

Another interesting feature of this flowering apex is the retention of a two-layered tunica, in which no periclinal divisions occur, at all times during its growth. The flower primordia are initiated by periclinal divisions in the third flank meristem layer from the surface. This is in contrast to the initiation of leaf primordia by periclinal divisions in the second flank meristem layer. It is significant that this initiation of flower buds is similar to that of vegetative buds. The two-layered tunica, present in the early flower primordia, is disturbed later by the initiation of the floral members in its second layer.

These observations on *Arabidopsis* have been found also to apply to *Capsella* and *Iberis*. So far as we are aware, no other record has been made of the persistence of the central initiation zone in the inflorescence apex. It would seem then that, so far as these plants are concerned, vegetative and inflorescence apices are essentially similar and that the profound differences claimed by Grégoire cannot be applied to them. The inflorescence apex of these Cruciferæ is essentially similar to any shoot growing-point producing lateral members while actively promoting longitudinal growth of its subjacent axis. It is intended to publish this work in detail in due course.

We are indebted to Prof. F. G. Gregory and Mr. G. Hussey for the plant material on which these observations were made, and also to the Central Research Fund of the University of London for the loan of a microscope.

John G. Vaughan
F. R. Jones
Dept. of Botany and Zoology, Chelsea Polytechnic, London, S.W.3. Feb. 5.

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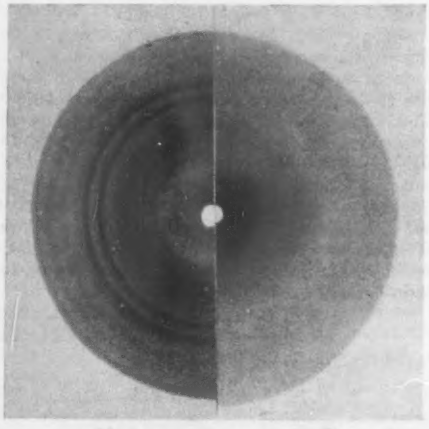
Variability in the X-ray Diagram of the Cell Walls of the Marine Alga *Spongomorpha*

In a recent communication[1] we have shown by the methods of X-ray analysis that the two closely related green algæ *Cladophora* and *Spongomorpha* differ fundamentally in the submicroscopic organization of their cell walls. Whereas the cells in *Cladophora* filaments have walls in which the skeletal substance is a highly crystalline, well-oriented native cellulose (cellulose I), those of *Spongomorpha* contain a poorly crystalline, scarcely oriented modification of cellulose which might be mercerized cellulose (cellulose II) or a derivative. It was pointed out some time ago[2] that the air-drying of the material, necessary for X-ray investigation, does not produce any undesirable artefacts in algæ, and it was therefore concluded that the structures derived in this way could legitimately be applied to the fresh material. Even preservation in formalin or alcohol does not cause any observable change in the X-ray diagram.

These conclusions still stand for *Cladophora* and therefore presumably for the whole group of algæ with the *Cladophora* type of structure. While making a re-examination of *Spongomorpha*, however, in preparation for a projected publication on this and other differences from *Cladophora*, it has been noticed that the X-ray diagrams of *Sp. lanosa* var. *uncialis* and of *Sp. arcta* (the only species we have yet examined from the point of view of this note) vary with the manner of specimen preparation. If the material is dried first and then washed in distilled water (the normal treatment), the X-ray diagram is of the type already published[1] (Fig. *b*) and leads to the interpretation of structure mentioned above.

If, however, the material is washed in distilled water while alive and then dried, the X-ray diagram is of an entirely different kind (Fig. *a*), showing many more lines and indicating a much higher crystallinity.

Some of the lines which appear in this second type of photograph are due to the presence of salts and have been identified as belonging to potassium chloride and sodium chloride. Others, however, undoubtedly arise from organic material. The number of these latter lines varies from collection to collection, and we are not certain whether or not this represents



(*a*) (*b*)

X-ray photographs of *Spongomorpha lanosa*: (*a*) specimen washed alive and then dried; (*b*) same specimen rewashed

a seasonal variation. Some of the lines show marked orientation, and we conclude that these correspond to material incorporated in the walls.

The change in the X-ray diagram is apparently caused by the extraction of substances from the walls, and the dried extracts yield X-ray diagrams containing several lines which have disappeared from the diagram of the filaments. The extract undoubtedly contains material from sources other than the wall, but we have nevertheless thought it necessary to carry out a preliminary chemical investigation. The material chars on heating and the elementary analysis is as follows: C, 16·6 ± 0·3 per cent; N, 2·15 ± 0·3 per cent; H, 2·51 ± 0·3 per cent; S, 2·49 ± 0·4 per cent; P, 0·0 per cent. It contains a good deal of SO_4'', which may account for some of the sulphur, though it should be remembered that even then the sulphur may be organic[3]. This material appears to consist in part of organic substances of the nature of soluble proteins, but carbohydrates are absent. Somewhat similar material is extractable from *Cladophora rupestris* but in much smaller quantity and without noticeable effect on the X-ray diagram.

Among the soluble substances, known to be present in algæ, the one yielding an X-ray diagram most similar to—indeed, almost identical with—that of our material has proved to be synthetic thetine (dimethyl β-carboxyethyl sulphonium bromide) presented to us by Prof. F. Challenger of the Chemistry Department at Leeds. Prof. Challenger has since shown that dead *Spongomorpha arcta* produces large quantities of dimethyl sulphide on treatment with water, so that it must contain substances of the thetine type.

We thus have here X-ray evidence that substances which appear to occur in the wall are nevertheless extractable only after the filaments have been killed. This is of great interest in view of the growing conviction that the wall of a cell is more than a mere dead envelope. If, in addition, these substances include thetine, a trans-methylating agent, then this might be a point of decisive importance. These points will be discussed elsewhere when the results can be presented in fuller detail.

The work reported here is part of a programme financed through a grant from the Department of Scientific and Industrial Research, to which the thanks of one of us (R. D. P.) are due.

E. Nicolai
R. D. Preston

Biophysics Sub-department,
Department of Botany,
University of Leeds. March 18.

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Differential Fluorescence in Identification of Tobacco Trashy Leaf

Trashy leaf is brown, worthless leaf occurring in flue-cured tobacco; its prevalence causes a substantial loss to the Australian tobacco industry[1]. In the investigation of this phenomenon, it is essential that means be available of detecting trashiness at an early stage in uncured leaf. Cured leaf can usually be separated on physical properties into several grades varying from normal to fully trashy. This does not apply to uncured leaf, where gradation in trashiness remains masked. A method is described here whereby the presence of trashiness in dried uncured leaf can be readily detected. This method is based on the differential fluorescence of normal and trashy leaves under ultra-violet light.

F *Fo*

Fig. 1. Typical normal (*F*) and trashy (*Fo*) uncured tobacco leaves under ultra-violet light

It has been observed that the underside, but not the upperside, of normal tobacco cured or uncured leaves fluoresces with a brilliant bluish-white light tinged with green when exposed to ultra-violet radiation. On the other hand, fully trashy leaves, whether cured or uncured, remain dull, showing only a reddish-brown colour (see Fig. 1).

Some chemical characteristics of cured and uncured trashy leaves have been reported previously[1]. It has now been found that absence of fluorescence is associated with the chemical composition typical of trashy leaf (that is, low sugar, carbohydrate and amide–nitrogen and high total nitrogen, protein–nitrogen and ammonia–nitrogen). The data in the accompanying table are for fluorescent (*F*) and non-fluorescent (*Fo*) leaf from the same stalk position obtained from two rows of plants, one normal and the other showing extensive trashiness. Over the past two years, the use of ultra-violet light has indicated the degree of trashiness that can be expected in the cured leaf.

Chromatographic separation in various solvents, and absorption spectrum measurement of the fluorescent fractions, indicate that fluorescence in

Per cent total sugars, total nitrogen and protein–nitrogen contents (dry-weight basis) in fluorescent (*F*) and non-fluorescent (*Fo*) uncured tobacco leaves, and reducing sugars in corresponding flue-cured leaves estimated by methods described in ref. 1. Values are the means of several estimations and do not deviate from the true mean by more than ± 0·30 for sugars and ± 0·02 for nitrogen

Leaf position on stalk	Total sugars		Reducing sugars		Total nitrogen		Protein–nitrogen in 'protein' preparation	
	(*F*)	(*Fo*)	(*F*)	(*Fo*)	(*F*)	(*Fo*)	(*F*)	(*Fo*)
5, 6, 7	37·9	17·0	17·1	3·9	1·43	2·52	1·74	2·82
8, 9, 10	43·1	14·8	19·6	3·6	1·38	2·69	1·74	2·92
11, 12	44·2	13·8	—	3·0	1·48	2·59	1·73	2·92

Fig. 2. Chromatogram of fluorescent components from normal (*F*) and trashy (*Fo*) leaves. These compounds are colourless in white light. *A* fluoresces with light grey, *B* with light blue, *C* with mauve and *D* (β-methylesculetin) with deep blue. (When taking the photographs a 2*A* Kodak haze filter was interposed between the object and camera lens)

tobacco leaf is a resultant of four major components *A*, *B*, *C* and *D*; typical chromatograms for normal and trashy leaves are shown in Fig. 2. The amount of fluorescent material present diminishes with increasing trashiness. There are indications that the relative amounts of the four components change as the fluorescence diminishes. Thus, there is a differential loss in component *C* with the development of trashiness. Component *D* has been isolated and identified as β-methylesculetin by comparison with an authentic sample. So far as is known, the difference in fluorescence of the two types of leaf and the presence of compounds represented by *A*, *B* and *C* has not been reported previously, although β-methylesculetin has been isolated from a variety of plants, including tobacco[2].

Further details of this work will be published elsewhere. I wish to express thanks to Miss I. D. Verners for sampling under ultra-violet light, and to Dr. R. J. Best of the Waite Agricultural Research Institute, Adelaide, for the authentic sample of β-methylesculetin.

R. Johanson

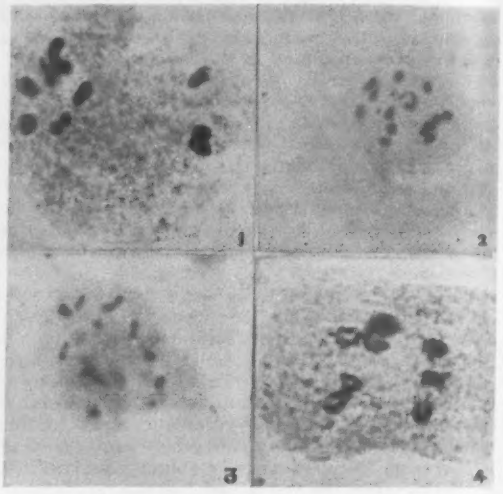
Division of Plant Industry,
Commonwealth Scientific and
Industrial Research Organization,
Canberra. Oct 29.

[1] Johanson, R., *Aust. J. Sci. Res.*, B, **4**, 231 (1951).
[2] Best, R. J., *Aust. J. Exp. Biol.*, **26**, 223 (1948). Andreae, W. A., *Nature*, **170**, 83 (1952).

Chromosomes of the Genus *Corchorus*

Banerji[1] was the first to study the chromosome numbers in the genus *Corchorus*, and he found that seven was the haploid number. His survey included two varieties of *C. olitorius* Linn., four varieties of *C. capsularis* Linn. and *C. acutangulus* Lamk. Later, Nakajima[2] confirmed the observations of Banerji in the case of *C. capsularis* Linn.

The behaviour of chromosomes in meiosis in a large number of *Corchorus* species has been studied in this laboratory. In *C. trilocularis* Linn., pairing is normal and seven bivalents are the rule, although occasionally two chromosomes fail to pair and appear as univalents.



(1) Pollen mother cell showing hyperploidy; seven bivalents in one group and one univalent and one bivalent in another group (*C. fascicularis*). (2) Meiotic metaphase of pollen mother cell showing $n = 14$ (*C. siliquosus*). (3) Polyploid pollen mother cell: $n = 14$ in diakinesis (thirteen bivalents are in focus) (*C. fascicularis*). (4) Pollen mother cell showing one quadrivalent and five bivalents (*C. fascicularis*)

C. siliquosus Linn. is a natural polyploid and fourteen bivalents appear at M_1 (Fig. 2). Multivalents are infrequent, which shows that this is a polyploid by age. Pollen mother cells with one quadrivalent and one trivalent or with two trivalents have also been observed.

In *C. fascicularis* Lamk., pairing leads to the formation of seven bivalents with a single nucleolus, and occasionally two univalents appear due to failure of pairing. Often two bivalents are in connexion with two nucleoli. This species appears to be a structural hybrid, because a quadrivalent appears frequently (Fig. 4). By far the most interesting feature in this species is the occurrence of pollen mother cells with fourteen bivalents along with those bearing the normal seven (Fig. 3). There is an indication that these polyploid cells elongate and the fourteen bivalents separate into two groups of seven bivalents each. Abnormal pollen mother cells have been recorded which have arisen due to irregularities in the pre-meiotic divisions. These hyper- and hypoploid cells show varying numbers. When the cell receives more than the normal seven, there is a tendency to eliminate the extra bivalents and thus one cell retains the normal seven bivalents (Fig. 1). These abnormalities are observed in several other species of *Corchorus* under investigation and appear to be a characteristic of this genus.

Lagging at anaphase has been noticed. Multipolar spindles are formed in the second division, leading to the formation of micro-nuclei.

Further details of this work will be published later. We thank Dr. K. V. Srinath for his guidance, and Dr. B. C. Kundu, director of this Institute, for his encouragement.

N. S. Rao
R. M. Datta

Department of Cytogenetics,
Jute Agricultural Research Institute,
Barrackpore, West Bengal. Oct. 21.

[1] Banerji, I., *J. Ind. Bot. Soc.*, **11**, 82 (1932).
[2] Nakajima, G., *Jap. J. Genet.*, **12**, 211 (1936).

Longevity and Production in the Buffalo

An attempt has been made to estimate the extent to which selection for yield might be expected to influence the productive life of the buffalo. The calculations were carried out on data from animals that were not in the course of their productive herd-life. These animals were either dead, or culled from the herds studied. They were grouped together within herds according to their number of calvings. The average first lactation yield for the different groups was calculated and expressed as a percentage of their herd average. The total results for the herds were obtained by weighting the relative yields in similar groups in the different herds according to the number of animals contributing to them.

No. of calvings	Relative yield (%)	σ (gallons)	C/V	No. of animals
1– 2	84·1	112·3	29·6	41
3– 4	94·2	106·4	28·3	81
5– 6	104·3	108·8	26·6	65
7– 8	116·6	116·6	24·5	34
9–11	108·7	94·2	20·4	29
		Average and total		
5·60	100	107·8	26·6	250

The above results showed that the average productive herd life of these animals was five calvings. The coefficient of variation of the first lactation milk yield decreased from the first to the eleventh calf. The increase in the first lactation yield with the number of calvings made in the herds could be due to culling of low producers on lactations after the first, owing to the repeatability 0·55. However, the high first lactation producers lived up to eight lactations, and animals living longer, and of relatively lower first lactation yield, might be those with which the farmers built up their herds.

K. A. Alim

Department of Animal Production,
Faculty of Agriculture,
Alexandria University.
Sept. 14.

Infectivity of Aphids after Several Hours on Tobacco infected with Potato Virus *Y*

Watson showed that fasted *Myzus persicæ* (Sulz.) were more than 60 per cent infective after 5 min. on tobacco infected with potato virus *Y*, but after 4 hr. on infected plants only about 10 per cent of the aphids were infective[1]. During investigations on the aphid transmission of potato virus *Y*, it was observed that, after several hours on tobacco, some aphids appeared to be feeding, others were just commencing to insert their stylets, and still others were wandering about the plant. The present communication reports which aphids transmit potato virus *Y* after a group has spent several hours on an infected plant.

Regular excretion of honeydew is generally accepted as evidence that an aphid is imbibing liquid from a plant[2], and previous work has shown that continuously feeding *M. persicæ* usually have the stylets inserted into the phloem[3]. To learn whether *M. persicæ* is infective after excreting regularly for more than an hour on tobacco infected with potato virus *Y*, single aphids were allowed to feed on infected leaves over filter paper which had been soaked in a solution of bromo-cresol green. Visible blue spots formed on the filter paper wherever drops of honeydew fell[4]. When an aphid fed continuously for more than an hour without changing its feeding site, three or four drops of honeydew fell on the paper within a circle of about 1 cm. diameter. Aphids that had excreted regularly for more than an hour from infected leaves were transferred to healthy White Burley tobacco plants (*Nicotiana tabacum* L.), and allowed to feed for several hours. Not one of twenty-five aphids tested in this manner transmitted the virus; but fasted aphids that spent 5 min. on the same infected plants were more than 60 per cent infective.

When feeding *M. persicæ* are gently disturbed with a camel's-hair brush, the stylets can be seen, with the aid of a hand-lens, extending beyond the tip of the proboscis. Aphids do not appear to be injured when disturbed in this way, for the proboscis slowly elongates over the stylets, and usually feeding is renewed within a few minutes. The length of the stylets visible immediately after an aphid is disturbed may be taken as the distance they were inserted into the plant. About twenty-five feeding aphids were disturbed, and dropped at once into a hot fixative. The distance that the stylets of each aphid extended beyond the tip of the proboscis was measured under a microscope, and the aphids were then observed with a × 15 hand-lens. After a little practice and with the dead aphids as standards, it was possible to tell at a glance whether the stylets of disturbed aphids extended 25–50 μ, 50–100 μ, or more than 100 μ. When aphids with their stylets inserted less than 25 μ were disturbed, the proboscis elongated so quickly that the stylets could rarely be seen. Furthermore, after several hours on a plant, nearly all aphids that appeared to be feeding had their stylets inserted more than 25 μ.

About fifty *M. persicæ* were transferred from cabbage to tobacco infected with potato virus *Y*. After a few hours on the infected plant, aphids that appeared to be feeding were disturbed, and the length of the stylets visible recorded as 25–50 μ, 50–100 μ, or more than 100 μ. Each aphid was then transferred to a healthy tobacco plant for several hours. Aphids were disturbed on various occasions from ten infected plants, and more than fifty aphids were tested for each of the three groups. A total of two hundred aphids was tested in all, but not one transmitted the virus. Disturbing the aphids did not appear to affect their ability to transmit, for aphids disturbed a second time about a minute after the stylets were re-inserted into the leaf were more than 30 per cent infective. Aphids that were observed to withdraw their stylets voluntarily, and disturbed about a minute after re-inserting their stylets, were also more than 30 per cent infective. Those aphids wandering about the leaves were observed to make a few feeding punctures lasting about a minute before settling down to continuous feeding. These aphids were transferred to healthy tobacco plants after they had completed one such puncture, and were more than 40 per cent infective. Thus, after several hours on tobacco infected with potato virus *Y*, virus was only transmitted by aphids commencing to insert the stylets, or by aphids that had made a brief feeding puncture.

The epidermis of the infected plants was about 20 μ thick. Therefore, aphids with their stylets inserted 25-50 μ must have only penetrated to the first or second mesophyll cells, and the majority of those with their stylets inserted more than 100 μ must have reached the phloem[5]. During feeding punctures lasting about a minute, the stylets are only inserted into the cells of the epidermis[5]. Thus, when

the stylets were inserted into the epidermis, *M. persicae* acquired potato virus *Y* that could later be used to infect healthy plants; and aphids are never, or only rarely, infective when the stylets have penetrated as far as the mesophyll or to the phloem.

R. H. E. Bradley

Field Crop Insect Laboratory,
Division of Entomology,
Canada Department of Agriculture,
Fredericton, New Brunswick.
Oct. 9.

[1] Watson, M. A., *Proc. Roy. Soc.*, B, **125**, 144 (1938).
[2] Broadbent, L., *Proc. Roy. Ent. Soc.*, A, **26**, 7 (1951).
[3] Roberts, F. M., *Ann. App. Biol.*, **27**, 348 (1940). Smith, K. M., *Ann. App. Biol.*, **13**, 109 (1926).
[4] Smith, L. M., *J. Agric. Res.*, **54**, 345 (1938).
[5] Bradley, R. H. E., *Ann. App. Biol.*, **39**, 78 (1952).

An Unusual Form of Carbon

In the course of experimental work on the deposition of carbon in the brickwork of blast furnaces (deposition which may cause the disintegration of the bricks), it has been found by electron micrography that the carbon is deposited as minute vermicular growths which can penetrate considerable thicknesses of brickwork. The carbon is formed by the interaction of carbon monoxide and iron oxide in the so-called iron-spots in the brick. It has been found possible to reproduce this reaction in the laboratory by exposing samples of brick containing iron spots to the action of carbon monoxide at an optimum temperature of about 450° C. Moreover, a similar form of carbon growth is observed if iron ore, magnetite or any form of iron oxide is substituted for the brick samples.

The carbon vermicules have a characteristic appearance which is easily recognized—they may vary in thickness from 100 A. or so up to about 0·2 micron, and they are generally somewhat helical in form. Stereoscopic examination has shown that many of the thicker threads consist of a number of thin ones twisted together in the form of a rope. We have, so far, been unable to find any other source of carbon of similar appearance, with the possible exception of soot from a domestic chimney where the same reaction may well have taken place.

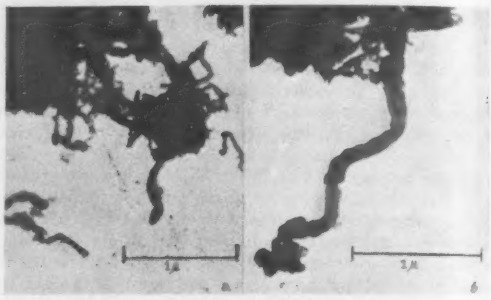
X-ray examination of the deposited carbon showed, in addition to amorphous carbon, cementite (Fe_3C) and an iron percarbide ($Fe_{20}C_9$). It is suggested, therefore, that the following reactions may take place:

$$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$
$$3Fe + 2CO \rightarrow Fe_3C + CO_2$$

$$Fe_3C \rightarrow 3Fe + C \qquad 20Fe_3C + 14CO \rightarrow 3Fe_{20}C_9 + 7CO_2$$
$$3Fe_{20}C_9 \rightarrow 20Fe_3C + 7C$$

Thus the reaction $2CO \rightarrow CO_2 + C$ may be considered to be catalysed either by iron which is alternately converted to cementite and back to iron, or by cementite which is alternately converted to the percarbide and back to cementite.

It would appear that the catalyst, whether it be iron or iron carbide or both, is formed originally as specks on the surface of the iron oxide—each speck giving rise to a thread of carbon. An isolated speck produces a thin thread, but the threads from a collection of catalytic points become twisted and probably coalesce to produce the characteristic vermicule. Once the growth of carbon has commenced, the position of the catalyst is less certain. We suggest that the particles of catalyst are located on the growing ends of the threads. This would explain the coalescence of multiple threads and also the mechanism by which the carbon can penetrate the bricks.



(*a*) Carbon growth in firebrick after 30 hr. in carbon monoxide at 450° C., showing mass of characteristic vermicular threads. (*b*) Large vermicule formed by coalescence of smaller threads

W. R. Davis
R. J. Slawson
G. R. Rigby

British Ceramic Research Association,
Queen's Road, Penkhull,
Stoke on Trent. Nov. 24.

Murex from the Red Sea

In the early months of 1951, Sir John Graham Kerr collected some three hundred *Murex tribulus* shells on the western shore of the Great Bitter Lake south of the village of Fayid. It will be remembered that the entire animal population has been introduced subsequent to the cutting of the Suez Canal in 1869, which opened the way for immigrant organisms from the Red Sea. Now, granted the inherent tendency of living creatures to vary when relieved of the shackles of environment, Sir John argued that, in their new environment of the Bitter Lakes, these *Murex* specimens had had an opportunity of responding to this tendency, and hence the remarkable variety of sculpture in the random collection. Moreover, this variation exhibited in spines and tubercles is not a matter of mere superficial markings, but rather of deep-seated causes such as the localized growth of the mantle edge or the depth in the mud occupied by the individual animal. The shells were in perfect condition, there being practically no tides in the Bitter Lakes and no violent wave action, and the bottom is soft mud.

Sir John very kindly presented me with this collection for the Notre Dame Museum. My successor in the lectureship at Notre Dame, Sr. Marie Josephine Parkes, has carried out a most painstaking investigation in detail of the variations shown by the individual shells, but is now held up at this point for lack of a corresponding series of shells from the open waters of the Red Sea. The object of this communication is to make an appeal for help to anyone with an opportunity for collecting in the Red Sea to fill this deficiency. A photograph of the particular species of *Murex* will be gladly forwarded to anyone willing to help.

Monica Taylor

Notre Dame College,
Dowanhill, Glasgow.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 27

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Sir Rudolph Peters, F.R.S.: "Inhibitors and Intracellular Chemical Dissection".* (Further Lectures on May 4, 11 and 18.)

UNIVERSITY OF LONDON (in the Eugenics Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Prof. W. Feller (Princeton): "On Diffusion Processes and their Statistical Applications".* (Further Lecture on April 29.)

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—"Induction and Scientific Legitimacy" (Chairman's Address).

ROYAL INSTITUTION, LIBRARY CIRCLE (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. E. Ironmonger: "The Tyndall Manuscripts".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. H. S. Taylor, F.R.S.: "Catalysis—Modern Trends".* (Further Lecture on April 28.)

Tuesday, April 28

WOOL EDUCATION SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.15 p.m.—Mr. John Barritt: "The Mothproofing of Wool".

Tuesday, April 28—Friday, May 1

LIBRARY ASSOCIATION (in the Pier Pavilion, Llandudno).—Annual Conference.

ROYAL SANITARY INSTITUTE (in the White Rock Pavilion, Hastings).—Health Congress.

Wednesday, April 29

IRON AND STEEL INSTITUTE (at 4 Grosvenor Gardens, London, S.W.1), at 9.45 a.m.—Special Meeting on "Boron in Steel".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. O. H. Wansbrough-Jones: "The Scientist's Place in the Services" (Sir William Jackson Pope Memorial Lecture).

TEXTILE INSTITUTE (at the University, Bristol), at 3 p.m.—Annual General Meeting; at 4 p.m.—Dr. C. M. Whittaker: "Common Sense and Colour in Textiles" (Mather Lecture).

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. George Wald (Harvard): "The Molecular Basis of Vision".*

GEOLOGICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting; Presidential Address on "The Evolution of the Shrinking Earth".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Dr. T. W. Wormell: "Lightning" (Symons Memorial Lecture).

Thursday, April 30

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Miss Edith Bülbring, Prof. J. H. Burn, F.R.S., and Miss Heather J. Shelley: "Acetylcholine and Ciliary Movement in the Gill Plates of *Mytilus edulis*"; Mr. F. W. Shotton: "The Pleistocene Deposits of the Area between Coventry, Rugby and Leamington and their Bearing upon the Topographic Development of the Midlands".

SOCIETY OF CHEMICAL INDUSTRY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. R. T. Colgate: "Science, Food and the People" (Third H. E. Armstrong Memorial Lecture).

CHADWICK PUBLIC LECTURE (in the Lecture Hall, Walker Art Gallery, William Brown Street, Liverpool), at 7.30 p.m.—Prof. S. E. Finer: "Public Health—a Comparison between the Age of Chadwick and our Own".*

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. H. S. Taylor, F.R.S.: "The Scientific Problems of Surface Catalysis".

Thursday, April 30—Friday, May 1

IRON AND STEEL INSTITUTE (at 4 Grosvenor Gardens, London, S.W.1).—Annual General Meeting.

Friday, May 1

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. J. Kampé de Fériet (Lille): "The Statistical Theory of Turbulence".*

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. J. Reeman, Mr. R. W. A. Buswell and Mr. D. G. Ainley: "An Experimental Single-Stage Air-cooled Turbine".

Friday, May 1—Saturday, May 2

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD AND AGRICULTURE GROUPS and the SOUTH-WESTERN SECTION, at Newton Abbot).—Symposium on "Potatoes as a Crop and an Industrial Raw Material".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN THE HISTORY OF MECHANICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (April 30).

ASSISTANT LECTURER IN BIOCHEMISTRY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1).

SENIOR ASSISTANT PHYSICIST IN THE RADIOTHERAPY AND X-RAY DIAGNOSTIC DEPARTMENTS—The Clerk to the Governors, St. Thomas's Hospital, London, S.E.1 (May 2).

LECTURER IN EXPERIMENTAL PHYSICS, and ASSISTANTS IN EXPERIMENTAL AND THEORETICAL PHYSICS—The Secretary, The University, Aberdeen (May 5).

ASSISTANT LECTURERS IN CHEMISTRY—The Registrar, The University, Manchester 13 (May 6).

ASSISTANT LECTURER IN BOTANY (preferably with special interest in ecology and morphology)—The Registrar, Queen Mary College, Mile End Road, London, E.1 (May 8).

EXPERIMENTAL OFFICERS (Ref. F.139/53A) and ASSISTANTS (Scientific) (Ref. F.140/53A) IN THE CHEMICAL INSPECTORATE, Ministry of Supply, for analytical work related to the Atomic Energy Production programme in establishments at Sellafield, Salwick, Capenhurst and S.E. London—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 9).

PH.D. in organic or biochemistry, for an applied chromatography research scheme—Dr. R. T. C. Pratt, National Hospital, Queen Square, London, W.C.1 (May 9).

SCHOLARSHIP IN THE SCHOOL OF THEORETICAL PHYSICS—The Registrar, Dublin Institute for Advanced Studies, 64 Merrion Square, Dublin (May 11).

GEOLOGISTS at the Geological Survey and Museum—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.168/53 (May 14).

ASSISTANT (male, with degree in horticulture, agriculture or botany) IN THE SCIENTIFIC LIAISON SECTION—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (May 16).

READER OR SENIOR LECTURER IN CIVIL ENGINEERING—The Registrar, The University, Nottingham (May 16).

SCIENTIFIC TECHNICAL OFFICERS for metallurgical and chemical research at the Central Research Establishment, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/623 (May 18).

ASSISTANT LECTURER IN STATISTICS—The Secretary, Bedford College, Regent's Park, London, N.W.1 (May 22).

SCIENTIST (Grade I) to supervise the design and operation of pilot plants—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, Glos, quoting TT/620 (May 23).

LECTURER IN PHILOSOPHY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

LECTURER IN GEOLOGY AND MINERALOGY—The Secretary, The University, Aberdeen (June 1).

PERRING SCHOLARSHIP IN AERONAUTICS—The Warden, College of Aeronautics, Cranfield, Bletchley, Bucks (June 1).

LECTURER (Grade II) IN CHEMISTRY (with special qualifications in physical chemistry, and who should have undertaken independent research in some branch of this subject other than reaction kinetics)—The Registrar, The University, Reading (June 13).

PHYSICIST (with university honours degree in science, or equivalent qualifications, with research experience in the use of X-ray diffraction, preferably as applied to studies of the structure of proteins or high polymers) TO THE BIOCHEMISTRY UNIT, Wool Textile Research Laboratories, Parkville, Melbourne, to participate in an intensive programme of research on the structure of wool and other fibrous proteins by chemical and physical methods—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 462/51 (June 26).

LECTURER IN MATHEMATICS at the University of Natal, Durban—The Secretary, Association of Universities of the British Empire, 5 Gordon Square, London, W.C.1 (June 30).

ASSISTANT PROFESSOR IN THE DEPARTMENT OF CIVIL ENGINEERING—The University of British Columbia, Vancouver, B.C., Canada.

ASSOCIATE PROFESSOR OF MATHEMATICS—The Acting Head of the Department of Mathematics, Memorial University of Newfoundland, St. John's, Newfoundland, Canada (apply by air mail).

BIOLOGIST (Fishery Research), Kenya, for survey of freshwater fisheries—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.152/7/01.

GEOLOGIST in Northern Rhodesia—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE. 105/3/01.

GEOLOGIST in Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.105/8/03.

LECTURER OR ASSISTANT LECTURER IN GEOLOGY, an ASSISTANT LECTURER and a DEMONSTRATOR IN ORGANIC CHEMISTRY—The Registrar, The University, Nottingham.

METALLURGIST (with honours degree or equivalent) to take charge of small metallurgical and chemical laboratory, and RESEARCH ENGINEERS (good honours degree essential) for (*a*) general automobile engineering problems, (*b*) investigations concerning mechanical properties (in particular, fatigue strength) of materials and components, (*c*) investigations into loadings experienced by vehicle components on the road, riding characteristics of vehicles, etc.—The Director, Motor Industry Research Association, Lindley, Nuneaton.

MINES SURVEYOR in Uganda—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE. 103/9/03.

PHYSICISTS (with at least second-class honours in physics, applied mathematics or engineering) for fundamental research on felt and applied research in the felt-making industry—The British Hat and Allied Felt-makers Research Association, Stanley House, Manchester Road, Fairfield, Droylsden, Manchester.

PROFESSOR OF EXPERIMENTAL PHYSICS, PROFESSORS (2) IN CHEMISTRY (one in physical chemistry), a PROFESSOR OF MATHEMATICS, a PROFESSOR OF GENERAL MECHANICS AND OSCILLATIONS (mechanics of continua), an ASSOCIATE PROFESSOR (general mechanics and vibrations), a SENIOR LECTURER IN PHYSICS (with special qualifications in nuclear physics or solid state physics), a SENIOR LECTURER IN CHEMISTRY, a SENIOR LECTURER in MATHEMATICS (with special qualifications in mathematical statistics), a SENIOR LECTURER IN THE DIVISION OF MECHANICS, PROFESSORS (2) IN THE DEPARTMENT OF CHEMICAL ENGINEERING (one with special qualifications in food technology and biotechnology), a PROFESSOR OF METALLURGY, PROFESSORS (2) OF ELECTRICAL ENGINEERING OR ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING, an ASSOCIATE PROFESSOR OF ELECTRICAL POWER ENGINEERING, a SENIOR LECTURER IN ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING, PROFESSOR OF MECHANICAL ENGINEERING (with special qualifications in thermodynamics and machines), a PROFESSOR OF HYDRAULIC AND/OR SANITARY ENGINEERING, an ASSOCIATE PROFESSOR OF HYDRAULIC AND/OR SANITARY ENGINEERING, an ASSOCIATE PROFESSOR (with special qualifications in tooling processes, machine tools and metrology), a SENIOR LECTURER (with special qualifications in applied thermodynamics and machine laboratory work), a SENIOR LECTURER OF HYDRAULIC AND/OR SANITARY ENGINEERING, a PROFESSOR OF ASSOCIATE PROFESSOR OF SENIOR LECTURER OF AIRCRAFT STRUCTURES, a PROFESSOR OF AIRCRAFT PROPULSION OR APPLIED AERODYNAMICS, an ASSOCIATE PROFESSOR OF AIRCRAFT PROPULSION OR APPLIED AERODYNAMICS and two SENIOR LECTURERS and a PROFESSOR or ASSOCIATE PROFESSOR IN FARM POWER AND MACHINERY; in the Hebrew Institute of Technology, Haifa, Israel—The Secretary, Technion Society of Great Britain, 13 Mansfield Street, London, W.1.

SENIOR RESEARCH FELLOWS and RESEARCH FELLOWS TO WORK IN THE DEPARTMENT OF THEORETICAL PHYSICS, Australian National University, Canberra, on problems of nuclear and particle physics and in field theory—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

SENIOR RESEARCH WORKER and a RESEARCH ASSISTANT, to undertake a fundamental study of the viscosity of liquid metals—The Registrar, The University, Edmund Street, Birmingham 3.

TECHNICAL OFFICER (with degree or diploma in agriculture, horticulture or biology) for potato trials—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Association of Universities of the British Commonwealth. Report of the Executive Council together with the Accounts of the Association for the Year 1st August 1951 to 31st July 1952. Pp. 21. (London: Association of Universities of the British Commonwealth, 1952.) [102

University of Cambridge: School of Agriculture. Memoir No. 24: A Summary of the Papers published by the Members of the Staff of the School of Agriculture and its Associated Research Organisations during the Period October 1st, 1951—September 30th, 1952. Review Series No. 7: Field Drainage Work at Cambridge, 1930–1952. Pp. 27. (Cambridge: School of Agriculture, 1953.) 2s. 6d. [102

The Graduate in the G.E.C. Pp. v+18. (London: General Electric Co., Ltd., 1953.) [102

Registrar General's Decennial Supplement, England and Wales 1931. Part 3: Estimates of Population, Statistics of Marriage, Births and Deaths, 1921–1930. Pp. vi+574. (London: H.M. Stationery Office, 1952.) 70s. net. [102

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 899, Vol. 245: The Hydrodynamics of Non-Newtonian Fluids, 3, The Normal Stress Effect in High-Polymer Solutions. By H. W. Greensmith and R. S. Rivlin. Pp. 399–428. 7s. No. 900, Vol. 245: On the Representation of Analytic Functions by Infinite Series. By W. F. Newns. Pp. 429–468. 9s. (London: Cambridge University Press, 1953.) [102

The Place of Wool in the World. Chart, 60 in. × 40 in. (London: International Wool Secretariat, 1953.) 5s. [43

Liverpool Observatory and Tidal Institute. Annual Report, 1952. Pp. 16. (Liverpool: Liverpool Observatory, 1953.) [43

Parliamentary and Scientific Committee. Annual Report, 1952. Pp. 24. (London: Parliamentary and Scientific Committee, 1953.) 1s. [43

National University of Ireland. Calendar for the Year 1952. Pp. 232. (Dublin: National University of Ireland, 1952.) [43

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 643, Vol. 237: The Reproduction of the African Elephant, *Loxodonta africana*. By Dr. J. S. Perry. Pp. 93–149. (London: Cambridge University Press, 1953.) 18s. [43

Inspection in Industry: Report of a Visit to the U.S.A. in 1951 of a Specialist Team on Inspection Methods in Industry. Pp. x+74. (London: British Productivity Council, 1953.) 3s. [43

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 2, No. 10: Structure and Igneous Activity in the Creag Strollamus Area of Skye. By Dr. Basil C. King. Pp. 357–402+4 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 15s. [43

Report of the Universities and Industry Conference organised by the Federation of British Industries and the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom and held at Ashorne Hill, Leamington Spa, 24–26 October 1952. Pp. vii+87. (London: Federation of British Industries, 1953.) 5s. [43

Annual Report for 1951 (No. 64) of the Marine Biological Station at Port Erin, Isle of Man. Drawn up by J. S. Colman. Pp. 32. (Liverpool: University Press of Liverpool, 1952.) 3s. [43

Annual Report of the National Oceanographic Council, 1951–52. Pp. vii+19. (Cambridge: At the University Press, 1953.) 5s. net. [43

Scientific Proceedings of the Royal Dublin Society. Vol. 26 (N.S.), No. 6: The Half Life of Calcium 45. By C. F. G. Delaney and J. H. J. Poole. Pp. 129–132. (Dublin: Royal Dublin Society, 1953.) 6d. [43

Sheffield City Libraries. Research Bibliographies (New Series), No. 61: Shell Moulding Practice (Croning or "C" Process). Pp. 3. (Sheffield: Central Library, 1953.) [53

Pharmaceutical Society of Great Britain. Calendar 1952–1953. Pp. vi+305. (London: Pharmaceutical Society, 1953.) 12s. 6d. [53

The *Engineer* Buyers' Guide, 1953. Pp. 608. (London: Morgan Bros. (Publishers), Ltd., 1953.) 5s. [53

Ministry of Education. List of Special Schools, Boarding Homes for Handicapped Pupils, and Institutions for Further Education and Training of Disabled Persons in England and Wales. (List 42.) Pp. 52. (London: H.M. Stationery Office, 1953.) 2s. net. [53

Manchester Museum: The University, Manchester. Report of the Museum Committee, 1951–1952. Pp. 28. (Manchester: Manchester Museum, 1953.) [53

Other Countries

Publications of the Dominion Obervatory, Ottawa. Vol. 14: Bibliography of Seismology. No. 10, Items 7653–7782, July to December 1951. By W. G. Milne. Pp. 195–210. (Ottawa: Queen's Printer, 1952.) 25 cents. [102

Kungl. Svenska Vetenskapsakademiens Handlingar. Fjärde Serien, Band 3, No. 3: Die Diatomeen von Schweden und Finnland. Von Astrid Cleve-Euler. Teil 5 (Schluss). Pp. 153+46 plates. 46 kr. Fjärde Serien, Band 3, No. 4: On the Skull of *Chirodipterus wildungensis* Gross, an Upper Devonian Dipnoan from Wildungen. By G. Säve-Söderbergh. Pp. 28+7 plates. 12 kr. (Stockholm: Almquist and Wiksell Boktrykkeri A.-B.; London: H. K. Lewis and Co., Ltd., 1952.) [102

United States Department of Commerce: Weather Bureau. Circular R: Preparation and Use of Weather Maps at Sea. Third edition. By Ivan R. Tannehill. Pp. vi+117. (Washington, D.C.: Government Printing Office, 1949.) 35 cents. [102

Geofisica e Meteorologia. Bollettino della Società Italiana di Geofisica e Meteorologia. Vol. 1, No. 1, Gennaio-Febbraio. Pp. 28. (Genova: Società Italiana di Geofisica e Meteorologia, 1953.) 3000 lire, 5 dollars, per annum. [102

Études de l'Institut Français d'Archéologie orientale du Caire. Études Sud-Arabiques, Tome 2: Les monuments de Ma'în (Yemen); étude épigraphique et philologique des 19 inscriptions de Ma'în publiées par le Prof. Mohammed Tawfik. Par Khalil Yahyâ Nâmi. Pp. vi+36. (Le Caire: Institut Français d'Archéologie orientale, 1952.) [102

Monograph Series of the Research Institute of Applied Electricity. No. 3: Some Researches on High Frequency Phenomena and Electrical Direct Heating. Edited by Y. Asami. Pp. v+105. (Sapporo: Hokkaido University, 1952.) [102

World Health Organization. Monograph Series No. 12: BCG Vaccination; Studies by the WHO Tuberculosis Research Office, Copenhagen. Report prepared under the direction of Dr. Lydia B. Edwards and Dr. Carroll E. Palmer, with the assistance of Knut Magnus. Pp. 307. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 960 French francs; 12 Swiss francs; 15s.; 3 dollars. [102

Deutscher Wetterdienst in der U.S.-Zone. Berichte des Deutschen Wetterdienstes in der U.S.-Zone. Nr. 42: Knoch-Heft. Pp. viii+463. (Bad Kissengen: Deutscher Wetterdienst in der U.S.-Zone, 1952.) 50 D.marks. [102

Food and Agriculture Organization of the United Nations: Indo-Pacific Fisheries Council. Proceedings, 3rd Meeting, 1st–16th February 1951, Madras, India. Section 1. Pp. 56. Sections 2 and 3. Pp. 57–227. Proceedings, 4th Meeting, Quezon City, Republic of the Philippines, 23rd October–7th November 1952. Section 1. Pp. 99. Indo-Pacific Fisheries Council. Special Publications No. 1: Fish-Culture in Brackish-Water Ponds of Java. By W. H. Schuster. Pp. xii+143+25 plates. (Bangkok: Indo-Pacific Fisheries Council, 1951–1952.) [102

Nigeria. Annual Report on the Forest Administration of Nigeria for the Year 1950–51. Pp. 64. (Lagos: Government Printer; London: Crown Agents for the Colonies, 1952.) 9d. net. [102

Western Australia: Geological Survey. Bulletin No. 105: Collie Mineral Field. By J. H. Lord. Pp. 274+11 plates. (Perth: Government Printer, 1952.) [102

Pacific Science Council Secretariat. Report, March 1951–December 1952. (Pacific Science Association Information Bulletin P8/52/9.) Pp. ii+28. (Honolulu: Pacific Science Council Secretariat, 1952.) [102

Institut Royal des Sciences Naturelles de Belgique. Mémoire No. 117: Les stromatoporoïdes du Dévonien moyen et supérieur du Bassin de Dinant, Deuxième partie. Par Dr. Marius Lecompte. Pp. 217–360+35 plates. Mémoire No. 121: Faune malacologique du Miocène de la Belgique, 2, Gastropodes. Par Maxime Glibert. Pp. 198+10 plates. Mémoire No. 122: Étude d'une biocénose—La frênaie à Carex (*Caricetoremotae-Fraxinetum* Koch, 1926). Par Dr. Albert Noirfalise. Pp. 186+2 plates. Mémoire No. 123: Introduction à l'étude des Tabanides et revision des espèces de Belgique. Par Dr. Marcel Leclercq. Pp. 80. Mémoire No. 124: Matériaux pour une monographie de *Trachelomonas* Ehrenberg, C., 1834, *Strombomonas* Deflandre, G., 1930, et *Euglena* Ehrenberg, C., 1832, genres d'*Euglénacées*. Par Walter Conrad et Ludo Van Meel. Pp. 176+19 plates. (Bruxelles: Institut Royale des Sciences Naturelles de Belgique, 1952.) [43

Institut Royal des Sciences Naturelles de Belgique. Mémoires, Deuxième Série, Fasc. 44: Les holothuries de Quoy et Gaimard. Par Gustave Cherbonnier. Pp. 50+3 plates. Mémoires, Deuxième Série, Fasc. 46: Gastropodes du Miocène moyen du Bassin de la Loire, Deuxième partie. Par Maxime Glibert. Pp. 239–450+15 plates. Mémoires, Deuxième Série, Fasc. 47: Polyplacophores de l'Océan Indien et des Côtes de l'Indochine française. Par Dr. Eugène Leloup. Pp. 70+6 plates. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1952.) [43

Catalogues

Catalogue of Books on Medicine and Allied Subjects. Pp. 84. Catalogue of Books on Electrical Engineering, Radio and Electronics. Pp. 28. (London: H. K. Lewis and Co., Ltd., 1953.)

Tools for Every Laboratory. Pp. 4. (London: Sunvic Controls, Ltd., 1953.)

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LECTURES AND COURSES

COLLEGE OF AERONAUTICS

A course of lectures on "Compressibility Effects in Aerodynamics" will be given at the College from Monday, May 11 to Friday, May 22, 1953. The course will cover both subsonic and supersonic flow and is designed to meet the needs of members of the aircraft industry or research establishments who wish to acquire a grounding in the subject and a guide to recent developments. Particular attention will be paid to problems of flight at high speeds. Fees for the course are: Tuition fee, £21; residence charge (including full board), £14.

Copies of the syllabus and form of enrolment can be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

COLLEGE OF AERONAUTICS

A course of lectures on Experimental Aerodynamics will be given at the College from Monday, July 13 to Friday, July 17, 1953. The course will cover the essential techniques and apparatus of a modern aerodynamic laboratory dealing with both high and low speed flow problems, and experiments and demonstrations will form an important part of the tuition. The course is elementary in scope, but is planned to provide a background of ordered practical wind tunnel experience. It is envisaged that the course will meet the needs of those who have recently joined or intend to join the aerodynamic laboratories of firms or research establishments. Some previous knowledge of fundamentals of elementary aerodynamics is essential. Selected applicants may, on request, be permitted to continue at the College for a second week to obtain further experience. Fees for the course are: Tuition fee, first week, £13 13s.; second week, £8 8s.; residence charge per week (including full board), £6 7s.

Copies of the syllabus and forms of enrolment can be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

(UNIVERSITY OF LONDON)
Incorporating the Ross Institute
NEWSHOLME LECTURES, 1953

A course of three lectures entitled "Child Health and the State" will be given at the London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), W.C.1, by Professor Alan Moncrieff, C.B.E., M.D., F.R.C.P., Nuffield Professor of Child Health, University of London, at 5.15 p.m. on May 19, 20, and 21, 1953. Lecture 1: Infant Welfare and the Ministry of Health. Lecture 2: School Health and the Ministry of Education. Lecture 3: The Deprived Child and the Home Office. Admission will be free and without ticket.

This is the fourth of an annual series of three lectures created under a Trust by the late Sir Arthur Newsholme, K.C.B., M.D., F.R.C.P., sometime Chief Medical Officer of the Local Government Board.

UNIVERSITY OF LONDON

A course of two lectures entitled "The Formation of Alkaloids in Plants" will be given by Dr. W. O. James (Oxford) at 5.30 p.m. on May 6 and 7 at the School of Pharmacy, 17 Bloomsbury Square, London, W.C.1.

Admission free, without ticket.

JAMES HENDERSON,
Academic Registrar.

UNIVERSITY OF LONDON

A lecture entitled "The Structure of Some Biologically Important Solids" will be delivered by Dr. R. W. G. Wyckoff (Science Attaché, American Embassy) at 5.30 p.m. on May 5 at University College (Chemistry Lecture Theatre), Gower Street, W.C.1.

Admission free, without ticket.

JAMES HENDERSON,
Academic Registrar.

CHELSEA POLYTECHNIC

MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY

A series of two postgraduate lectures on "Moving fronts in Porphyrin Chemistry and Biochemistry" will be given by J. E. Falk, Esq., M.Sc., Ph.D., of University College Hospital Medical School on the Mondays May 11 and 18, at 7.30 p.m. Fee for the course, 5s.

A leaflet giving further particulars can be obtained by application to the Secretary of the Polytechnic.

GRESHAM COLLEGE

BASINGHALL STREET, LONDON, E.C.2

Four Lectures by Professor H. Hartridge, M.A., M.D., Sc.D., M.R.C.P., F.R.S. (Gresham Professor in Physic), on "The Physiology of Vision —Part 2," on Monday to Thursday, April 27 to April 30.

The lectures are free and begin at 5.30 p.m.

UNIVERSITY OF LONDON

A lecture entitled "The Productivity of Scientists" will be given by Professor Wayne Dennis (Brooklyn College, New York), at 5.30 p.m., on April 30 at University College (Anatomy Lecture Theatre), Gower Street, W.C.1.

Admission free, without ticket.

JAMES HENDERSON,
Academic Registrar.

OFFICIAL APPOINTMENTS

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18 to 64 inclusive, or a woman aged 18 to 59 inclusive, unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

CORPORATION OF THE CITY OF ABERDEEN

HEALTH AND WELFARE DEPARTMENT
PART-TIME STATISTICIAN

Applications are invited for the post of Statistician (part-time) in the Health and Welfare Department of the Corporation. The salary scale for the post is £310 per annum, rising by annual increments of £15, to £400 per annum for a 20-hour week. Applicants must be graduates of a British University, with an honours degree, and must have had statistical experience.

Applications, stating age, and giving particulars as to training and experience, and accompanied by one copy of each of three recent testimonials, should be lodged with the Medical Officer of Health, Willowbank House, Willowbank Road, Aberdeen, on or before Saturday, May 2, 1953.

J. C. RENNIE,
Town Clerk.

Town House,
Aberdeen.

UNIVERSITY OF CAPE TOWN

(SOUTH AFRICA)
LECTURERS IN STATISTICS AND APPLIED MATHEMATICS

Applications are invited for Lectureships in Statistics and Applied Mathematics in the Department of Mathematics. The salary scale is £550 by £25 to £800 per annum. There is also a temporary cost of living allowance; at present £320 per annum for a married man and £144 per annum for a single person. A Government commission is at present inquiring into salary scales for staffs of universities and improvement of scales is hoped for in 1953.

Applications (with copies of testimonials), should state age, experience, qualifications, and research work completed or in progress, and give the names of two referees whom the university may consult. Two copies of the application and testimonials, should reach the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (from whom further particulars and a memorandum giving the general conditions of appointment should be obtained) not later than May 30, 1953. An additional copy should be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa. The University reserves the right to appoint a person other than one of the applicants or to make no appointment.

UNIVERSITY OF HONG KONG

Applications are invited for the vacant post of Lecturer in Economics. Emoluments (for a married member of the staff normally resident outside Hong Kong or China, and inclusive of allowances): £1,400 by £40 to £1,640 per annum. Applicants should be honours graduates of British universities, and have appropriate qualifications and experience, and should be prepared to take up the post by September, 1953. First-class sea passages and furnished houses or flats at reasonable rentals are provided for expatriate staff.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1. The closing date for the receipt of applications in London and Hong Kong is May 31, 1953.

CITY OF LEEDS

WATERWORKS DEPARTMENT
APPOINTMENT OF CHEMIST AND BACTERIOLOGIST

Applications are invited for the appointment of Chemist and Bacteriologist. Candidates must have obtained a university degree and/or other professional qualifications, and must have had experience in the bacteriological, as well as the chemical, examination of water. The salary for the post is in accordance with Grade APT IX of the National scheme of conditions of service, namely, £815 to £935 per annum. The appointment is subject to the provisions of the Local Government Superannuation Act, 1937. The selected candidate will be required to pass the Corporation's medical examination. The person appointed will be required to devote the whole of his time to the business of the Corporation, and will not be allowed to engage either directly or indirectly in private work of any kind. The appointment will be subject to one month's notice on either side.

Applications, on forms to be obtained from the undersigned, should be delivered not later than 12 noon on Wednesday, May 6, 1953. Canvassing in any form, either directly or indirectly will be a disqualification.

KENNETH L. FORSTER, M.I.C.E.,
General Manager and Engineer.

Waterworks Department,
Civic Hall,
Leeds, 1.

UNIVERSITY OF NATAL

DURBAN, SOUTH AFRICA
PROFESSOR OF PATHOLOGY

Applications are invited from medical practitioners (registered or registrable with the South African Medical and Dental Council), for the post of Professor of Pathology in the Faculty of Medicine in the University of Natal, Durban, at a salary of £2,500 per annum, plus a temporary cost of living allowance (which is at present £320 per annum). The appointment will be made jointly by the University and the Natal Provincial Administration and the incumbent of the post will be ex-officio Pathologist-in-Charge of the provincial pathological laboratory attached to the King Edward VIII (non-European) Hospital, which is immediately adjacent to the medical school and will be the teaching hospital for the school. Allowance is made for travelling expenses.

Further particulars and information as to the method of application, may be obtained from The Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1. Closing date for the receipt of applications is May 11, 1953.

UNIVERSITY OF GLASGOW

SENIOR LECTURESHIP IN VETERINARY MEDICINE

Applications are invited for the appointment of a Senior Lecturer in the Department of Veterinary Medicine in the University Veterinary School. The applicant should have a general experience of veterinary practice, and have a particular knowledge of veterinary medicine in relation to farm animals and metabolic diseases. Salary scale: £1,150 to £1,400. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (six copies) should be lodged not later than May 15, 1953, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

ROYAL HOLLOWAY COLLEGE

UNIVERSITY OF LONDON
ASSISTANT LECTURESHIP IN CHEMISTRY

The Council invites applications for the post of Assistant Lecturer in Chemistry, tenable from October 1, 1953. The appointment is open to men and women equally. Salary will be on the scale approved by the Senate of the University of London.

Applications are required not later than May 15, 1953. Full particulars may be obtained from the Principal, Royal Holloway College, Englefield Green, Surrey.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF PHYSICS

Applications are invited for appointment as Professor or Reader in Theoretical Physics from October 1, 1953.

The conditions of appointment and form of application may be obtained from the undersigned, to whom completed applications should be sent not later than May 16, 1953.

H. PICKBOURNE,
Registrar.

COLLEGE OF AERONAUTICS

Applications invited for a post of Lecturer in the Department of Aerodynamics. This post becomes vacant in August, 1953. The successful applicant will be expected to take an active part in the teaching and research work of the laboratory, which is well equipped with modern high and low speed wind tunnels. Salary within the range of £600 to £1,000 per annum, with superannuation under F.S.S.U. and family allowance, initial salary depending upon previous experience and qualifications. Small house or single accommodation available.

Applications, giving full particulars and containing names and addresses of not more than three referees, to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks, not later than May 8, 1953. Further particulars available.

ST. THOMAS' HOSPITAL

LONDON, S.E.1

Applications are invited for the post of Senior Assistant Physicist for duties in the Radiotherapy and X-ray Diagnostic Departments of the hospital. Applicants must possess an honours degree in physics and have had experience in hospital physics. Some facilities for research will be available to the successful candidate. The salary of the post will be that appropriate to the Senior Grade in the Whitley Council scales for physicists —i.e., £835, rising to £1,080 per annum, plus London weighting.

Applications, giving the names of three persons to whom reference may be made, should be sent within fourteen days of the appearance of this advertisement, to the Clerk of the Governors, from whom further information may be obtained.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for appointment as Reader or Lecturer (Grade I) in Metallurgy. Candidates must have had teaching, research, and practical experience. Salary scales: Reader £1,100 to £1,600; Lecturer £1,100 to £1,300.

The conditions of appointment and form of application may be obtained from the undersigned, to whom applications must be sent not later than May 16, 1953.

H. PICKBOURNE,
Registrar.

BATTERSEA POLYTECHNIC

LONDON, S.W.11

Applications are invited from suitably qualified graduates of a British university for the post of Grade B Lecturer in the Department of Mathematics, to commence duties on September 1, 1953. The lecturer will be mainly concerned with the training of students for the intermediate and final degree examinations of the University of London. Salary £586 or £598 by £25 to £873, plus training allowance, less statutory deductions. Increments for approved experience.

Further particulars may be obtained from the Clerk to the Governing Body by whom applications should be received not later than May 9.

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL

Laboratory technician required (male) in the Medical Unit. Biochemical experience essential. Salary according to Whitley Council scale.

Applications should be made in writing to the Secretary of the Medical School, University Street, London, W.C.1.

MINISTRY OF SUPPLY. SENIOR PRINcipal Scientific Officer. Directorate of Electronics Research and Development, London. The Civil Service Commissioners invite applications for a permanent and pensionable appointment. Candidates must have been born on or before December 31, 1921. Required to plan and coordinate all electronic research in the Ministry to review continually the whole field of electronics and advise on the need to initiate new lines of research, particularly of a basic nature. Candidates must have first- or second-class honours degree in physics or electrical engineering, or equivalent qualification, provided that a candidate without this qualification but of high professional attainments may be considered. Candidates should have had several years' experience in electronics, with responsibility for experimental and development work. Inclusive salary scales: Men, £1,600 to £1,850; women, £1,423 to £1,680. Starting salary determined on assessment of successful candidate's qualifications and experience. —Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S4197/53. Application forms to be returned by May 7, 1953.

SOUTH WARWICKSHIRE HOSPITAL GROUP (NO. 14)

Applications are invited for the post of Assistant Biochemist (Basic Grade), to work under the general direction of the Group Pathologist. Candidates should possess a university degree or equivalent. Duties to include cardio-respiratory physiological chemistry and general hospital biochemistry. Training in the techniques will be provided. Opportunities for research. Salary according to Whitley Scale. Applicants may visit the laboratories.

Applications, including names of three referees, should reach the Group Pathologist, Group Pathological Laboratory, Lakin Road, Warwick, not later than May 11, 1953.

UNIVERSITY OF ABERDEEN

NATURAL PHILOSOPHY DEPARTMENT

Applications invited for Lectureship in Experimental Physics. Salary scale £550 to £800 or £800 to £1,100 per annum (initial placing according to qualifications and experience), with F.S.S.U. and children's allowances. Part of furniture removal expenses to Aberdeen refunded.

Conditions of appointment and forms of application should be obtained from the undersigned, with whom applications (eight copies) should be lodged by May 5, 1953.

W. S. ANGUS,
Secretary.

The University,
Aberdeen.

UNIVERSITY OF ABERDEEN

NATURAL PHILOSOPHY DEPARTMENT

Assistants in Experimental and Theoretical Physics required. Salary in range £450 to £550 per annum, according to qualifications, with F.S.S.U. and children's allowances.

Applications, not later than May 5, 1953, to the undersigned, from whom particulars and forms of application should be obtained.

W. S. ANGUS,
Secretary.

The University,
Aberdeen.

MINISTRY OF SUPPLY REQUIRE ENGINeer at Harwell to control, under Assistant Director, large engineering workshop making wide range experimental apparatus. Qualifications: recognized engineering apprenticeship and A.M.I.C.E. or Mech.E. or Elec.E. or exempting qualifications. Management experience manufacturing workshop and staff control essential. Experience progressing, planning, and detail knowledge modern welding desirable. Salary: £1,256 to £1,454. Appointment temporary, but opportunities to compete for establishment may arise.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting ref. C.193/53A. Closing date May 9, 1953.

BRITISH ELECTRICITY AUTHORITY REquire a Biologist in the Generation Operation Branch at Headquarters in London, with a first- or second-class honours degree. Duties will be to study the effects of power station operation upon the life of rivers and other water-ways, in general and in relation to specific power stations. Every facility will be given to study techniques in this new field. The post is based in London, but the holder may be required to spend short periods at any power station in the country. Salary N.J.B. General Assistant Engineer, Grade 5, £558 to £769 inclusive.—Applications, stating age, qualifications, experience and present salary, to D. Moffat, Director of Establishments, Winsley Street, London, W.1, by May 19, 1953. Quote reference N/364.

MINISTRY OF SUPPLY REQUIRES ELECtrical Engineers and Physicists for interesting research or development work at Malvern, Worcs, on radar equipment for Forces. Opportunity to acquire good knowledge of microwave techniques. Qualification for research posts is first- or second-class honours degree or equivalent in appropriate subject. Grade, Scientific Officer £417 to £675. F.S.S.U. benefits may be available (ref. A 92/53/A). Qualification for development work is higher school certificate (science) or equivalent, although further training in physics or electrical engineering may be an advantage. Grades, Experimental Officer (minimum age 26) £597 to £754, or Assistant Experimental Officer £264 (age 18) to £555 (ref. A 337/52/A). All posts unestablished. Salaries according to age and experience. Rates for women somewhat lower.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference. Closing date May 16, 1953.

BIRKBECK COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited for the post of Lecturer in Zoology. Candidates should have a special interest in entomology. Salary scale £600 by £50 to £900 then £900 by £50 to £1,150 per annum.

Further particulars should be obtained from the Secretary, Birkbeck College, Malet Street, London, W.C.1, with whom applications must be lodged not later than May 16, 1953.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for appointment as Reader or Senior Lecturer in Civil Engineering. Candidates should have had teaching, research, and practical experience. Salary within the range £1,100 to £1,600.

The conditions of appointment and form of application may be obtained from the undersigned, to whom applications must be sent not later than May 16, 1953.

H. PICKBOURNE,
Registrar.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MATHEMATICS

Applications are invited for appointment as Professor or Reader in Applied Mathematics from October 1, 1953.

The conditions of appointment and form of application may be obtained from the undersigned, to whom completed applications should be sent not later than May 16, 1953.

H. PICKBOURNE,
Registrar.

UNIVERSITY OF READING

ASSISTANT LECTURESHIP IN MATHEMATICS

The Council invites applications for the post of Assistant Lecturer in Mathematics. Salary £450 per annum, rising by annual increments of £25 to £500 per annum.

Further particulars may be obtained from the Registrar, The University, Reading, by whom applications should be received not later than May 9, 1953.

MINISTRY OF SUPPLY, RESEARCH Establishment, S.E. London, requires Physicist to assist in work involving application of electron microscopy to explosives and metallurgical problems. Qualifications: Higher school certificate (science) or equivalent; but higher qualifications—e.g., degree—may be an advantage. Previous experience in electron microscopy not essential, but experience involving advanced metallographic techniques required and knowledge of high vacuum techniques and electronics an advantage. Salary within range, Experimental Officer (minimum age 26), £628 to £786. Women somewhat less. Post unestablished.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 93/53/A. Closing date May 16, 1953.

THE EDINBURGH AND EAST OF SCOTland College of Agriculture invite applications for Plant Physiologist in Botany Department. Candidates should possess recognized qualifications and have accomplished some research. Duties consist of lectures, laboratory work, etc. Ample time allowed for research with particular reference to agricultural and horticultural problems in college area. Salary: Grade III (Int.) £535 to £855, plus pay addition of £51 14s. to £67 18s.—Application forms and further particulars from Secretary, 13 George Square, Edinburgh, with whom they should be lodged within two weeks of the appearance of this advertisement.

TECHNICIAN REQUIRED TO ASSIST IN Biochemical Research at the Pollards Wood Research Station (Chalfont St. Giles, Bucks), of the Institute of Cancer Research: Royal Cancer Hospital. Applicants should be well qualified, and experience in the field of the chemistry and biochemistry of viruses will be an advantage. Salary will be according to age, experience and qualifications, and the post is superannuable.—Applications should be addressed to reach the Secretary, Institute of Cancer Research: Royal Cancer Hospital, Fulham Road, London, S.W.3, on or before April 30, 1953.

REQUIRED, PH.D. IN ORGANIC OR BIOchemistry, salary £700 to £1,000, according to experience, for an applied chromatography research scheme, to commence as soon as possible. —Applications, with the names of two referees, to be sent to Dr. R. T. C. Pratt, The National Hospital, Queen Square, London, W.C.1, by May 9, 1953.

UNIVERSITY OF LONDON

The Senate invite applications for the Readership in Civil Engineering, tenable at the Imperial College of Science and Technology (salary £1,050 to £1,250 to £1,450 a year).

Applications (ten copies) must be received not later than May 11, 1953, by the Academic Registrar, University of London, Senate House, W.C.1, from whom further particulars should be obtained.

THE BRITISH RAYON RESEARCH ASSOciation requires the services of a Physical Chemist, for work on the oxidation of cellulosic materials. Salary in accordance with age and experience. Superannuation under the Federated Superannuation System for Universities.—Apply to the Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

SENIOR BIOCHEMICAL TECHNICIAN REquired for biophysics laboratory. Duties include carrying out and supervising biochemical preparations and analyses and supervising care of equipment. Glassblowing ability an advantage. Salary according to experience.—Apply Professor J. T. Randall, Wheatstone Physics Laboratory, King's College, Strand, London, W.C.2.

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Details of experience and qualifications should be sent to Personnel Manager, Messrs. Joseph Lucas (Gas Turbine Equipment), Ltd., Shaftmoor Lane, Hall Green, Birmingham.

THE STAVELEY IRON & CHEMICAL COMpany, Limited, invite young graduates in chemistry, who have completed their military service, to apply for a post in the Research Department. The successful applicant will be given the opportunity to familiarize himself with the chemical activities of the company whilst being employed initially upon selected projects connected with heavy chemicals.—Applications should be made in writing to the Research Manager, Staveley Iron & Chemical Co., Ltd., Hollingwood, near Chesterfield.

LARGE OIL COMPANY HAS IMMEDIATE opening for male graduate with honours degree in either agriculture or horticulture for work in London office, on the overseas marketing side. Suitable man should not be over 30 years of age and with preferably two or three years' practical agricultural experience. Expenses paid for interview in London.—Write, giving full details experience, age, marital status, in first instance to Box Z.U.832, Deacon's Advertising, 36 Leadenhall Street, E.C.3.

SENIOR ASSISTANT REQUIRED FOR control laboratory of pharmaceutical manufacturing company in a specialized field. Applicants must have either an honours degree in chemistry or equivalent pharmaceutical qualification and have some laboratory experience. Salary will be in accordance with qualifications and experience.—Write, giving full details to Box 604, T. G. Scott & Son, Ltd., Crown House, 143-147 Regent Street, London, W.1.

Advertisers please note. You must add "Apply Employment Exchange" unless the employment advertised or the workers required are excepted under the Notification of Vacancies Order.

GRADUATE SCIENTISTS. BRITISH Nylon Spinners Limited will shortly have a number of vacancies in their research organization resulting from a major expansion of their laboratories at Pontypool. There will be attractive opportunities for Physicists and Chemists (both Physical and Organic) in a wide field of work embracing fundamental bench research and applied work in a large experimental plant. Some of these positions will be suitable for new graduates, others for men with experience in industrial research or significant post-graduate achievements at a University. In all other cases candidates must have either a first- of second-class honours degree. The general prospects for really first class research workers are probably above average and all appointments will carry good starting salaries. The facilities and working conditions are of a high standard and the Company gives the fullest support and encouragement to its research staff. The successful candidates will be those who, in addition to academic distinction and research achievements, have also a natural inclination for team work and ability to co-operate. —Candidates who are still at a University can in most cases obtain further details from the University Appointments Board, but applications in all cases can be sent to the Personnel Manager, Pontypool, Mon.

FOOD TECHNOLOGIST REQUIRED AS executive head of a central department of applied science sited in London as an autonomous unit to serve an expanding group of factories. Applications are invited from men in the age range 35 to 45 years who have high academic qualifications and some experience of food processing. Specialist training in colloid science or in carbohydrates and protein chemistry would be an advantage. Familiarity with the main principles of chemical engineering is essential. Personality and proved ability to lead a team of chemists, physicists and chemical engineers will carry great weight in assessing applicants for a short list. This vacancy relates to an outstanding job in the British food industry, and is rewardable accordingly. Contributory pension scheme. Housing assistance given if required. The fact that this vacancy has already been advertised and is now repeated indicates the great importance which the Advertisers attach to securing the right man.—Write Box N.211, c/o 191, Gresham House, E.C.2.

DEVELOPMENT ENGINEER REQUIRED by technical division of West London light engineering company, to work on development of new manufacturing processes. Essential requirements are degree in mechanical engineering, with background knowledge of physics and some works experience or degree in physics, with considerable experience of mechanical engineering. Initial salary in region of £550 to £725.—Write Box N.2636, A. K. Advs., 212a Shaftesbury Avenue, W.C.2.

PHYSICISTS AND ENGINEERS WHO ARE interested in working on problems in connection with transformers and high voltage transmission equipment are invited to apply for positions which are vacant at the Stafford Works of the English Electric Company Ltd. Suitably qualified candidates may be given special advanced training.—Write giving full details, quoting ref. 225K, to Central Personnel Services, Marconi House, 336-7 Strand, London, W.C.2.

DECCA RADAR, LTD., INVITES APPLIcations from young scientists and engineers due to graduate this year, and who expect to get good honours degrees. The posts offer interesting and well paid careers in radar engineering for young men who are prepared to work hard. British nationality essential.—Write, quoting ref. CPH, to Decca Radar, Ltd., Research Laboratory, 2 Tolworth Rise, Surbiton, Surrey.

SANDOZ PRODUCTS, LIMITED, INVITE applications from candidates for the position of Assistant in the Medical Information Department. Applicants should be under 35 years of age and have a high standard of education, enabling them to have a good English prose style; a scientific background (medicine, chemistry or pharmacy) is desirable but not essential. The position is permanent and is situated in London.—Applicants are requested to submit full particulars of training, qualifications, and experience, together with a recent photograph, to the Personnel Manager, 134, Wigmore Street, London, W.1.

SENIOR DEVELOPMENT ENGINEERS ARE required for work on small electro-mechanical devices. High technical and personal characteristics are essential and a university degree is desirable. The positions hold promise of considerable responsibility and involve control of staff. Salary is commensurate with ability and experience. Excellent working conditions in modernly equipped laboratories. Bus services to Kingston, London, Guildford, pass the premises. Five-day week, canteen, pension scheme, sports and social club with recreational facilities.—Applicants must be of British nationality and should submit details of age and experience to The Manager, Cottage Laboratories Ltd., Portsmouth Road, Cobham, Surrey.

ORGANIC CHEMIST. VACANCY IN recently established chemical factory in N. Lincolnshire for well qualified organic chemist, preferably with good university degree. Candidates should have had some years' experience in full charge of substantial production—e.g., of dyestuff intermediates or fine chemicals. The man appointed will be responsible to the factory manager initially for part of the production programme. There are good prospects for a man able to accept authority and win the confidence of those working under and over him. Age preferably between 35 and 45. Starting salary not less than £1,200 with excellent contributory pension fund. —Apply Box 603, T. G. Scott & Son, Ltd., Crown House, 143-147 Regent Street, London, W.1.

PETROLEUM COMPANY REQUIRES MALE or female graduate with honours in entomology for work in London office in connection with overseas marketing of agricultural products. Two or three years' practical agricultural experience desirable, but not essential. Maximum age limit 30 years. Permanent career with pension scheme. —Write, giving full details to Box Z.Q.824, Deacon's Advertising, 36 Leadenhall Street, E.C.3.

THE BRITISH DRUG HOUSES, LTD., have a vacancy in their chemical research laboratories for a young Organic Chemist (male), preferably with an interest in biochemistry, for work in the insulin field. Salary according to age, qualifications and experience. Five-day week. Canteen, pension and profit-sharing schemes.—Apply, in writing, stating age, qualifications and experience, to Staff Manager (GMG/VP.M 3117), Graham Street, City Road, N.1.

BRITISH CELANESE LIMITED, MANUFACturers of textiles, plastics, and chemicals, have a few vacancies in research, development, and production work for well qualified and able chemists, physicists, engineers, and textile technologists, aged 25 to 35 years. There are prospects of rapid promotion for outstanding men who possess initiative, drive, and application. Starting salary and increments will be commensurate with the responsibilities undertaken. Contributory pension fund.—Applicants should send full details, including present salary in confidence to the Personnel Manager, British Celanese Limited, Celanese House, 22-23 Hanover Square, London, W.1.

LARGE PETROLEUM ORGANIZATION requires for London office for technical planning of marketing development and survey work on chemicals, Organic Chemist of resource and creative imagination, under 30 years of age. First- or second-class honours degree necessary, two or three years experience in the chemical industry desirable, but not essential. Permanent post. Pension scheme. Salary in accordance with qualifications and experience.—Write, giving full details to Box Z.S.828, Deacon's Advertising, 36 Leadenhall Street, E.C.3.

DECCA RADAR, LTD., INVITES QUALIfied and experienced scientists to apply for a post in the Research Laboratories to undertake operational research studies on radar systems. The post is senior and carries a commensurate starting salary. There is a pension scheme in operation. Applicants must be of British nationality, and be prepared to work, when required by the company, anywhere in Europe.—Write, quoting ref. SRT. A., The Research Director, Decca Radar, Ltd., The Research Laboratories, 2 Tolworth Rise, Surbiton, Surrey.

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HAS ANY UNIVERSITY, COLLEGE, Museum, School, or Hospital got a very large Induction Coil for disposal, of the type that was used in antique X-ray apparatus.—Write, Box No. 5197, c/o Whites Ltd., 72 Fleet Street, London, E.C.4.

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Coke Research Fellowship of £350 per annum for research in the Department of Fuel Technology. Tenable for one year, from October, 1953; renewable for a second year. Ellison Research Fellowships (three) of at least £260 per annum, with remission of fees for research in chemistry or physics. Tenable for three years from October 1, 1953. C.G. Carlisle Research Scholarship for research in Metallurgy. Value £70 per annum, may be supplemented by the Ministry of Education up to the value of a State Scholarship. Tenable for one year from October, 1953, renewable for a second and a third year. The above awards are open to graduates of British universities.

Full particulars may be obtained from the undersigned, to whom applications should be sent not later than June 12, 1953.

A Research Scholarship of £350 per annum for research work connected with the chemistry of amino acids, peptides, and proteins. Tenable from October, 1953, and renewable up to a period of three years, subject to satisfactory progress.

Applications, giving full particulars of qualifications, and the names of two referees must be made to the undersigned not later than June 1, 1953.

A. W. CHAPMAN,
Registrar.

UNIVERSITY OF MANCHESTER

RESEARCH STUDENTSHIPS IN SCIENCE

Applications are invited for the above studentships, normally tenable for three years and of the value of £300 per annum. Candidates must hold the degree of Bachelor or Master of a British university other than Manchester.

Applications should be sent not later than July 1, 1953, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF SOUTHAMPTON

ESSO RESEARCH STUDENTSHIP

Applications are invited from men with a good university degree, with chemistry as principal subject, for a Research Studentship in Chemistry, endowed by the Esso Petroleum Co., Ltd., at £260 per annum, to commence October 1, 1953.

Candidates should apply to the Professor of Chemistry, from whom further particulars can be obtained, before May 16, 1953.

MCMASTER UNIVERSITY

DEPARTMENT OF BIOLOGY
GRADUATE ASSISTANTSHIPS

Applications are invited for part-time teaching and research assistantships in the Department of Biology, McMaster University, from students qualified to register for study leading to the M.Sc. and Ph.D. degrees. Assistantships normally carry a yearly stipend of $600 to $1,200. Assistants are required to devote 10 to 12 hours per week to duties during the academic session (October to April inclusive) and are able to work full-time at their research during the summer. Research is in progress in the following fields: Ecological studies of black flies, D. M. Davies. Ecology of the field mouse, *Microtus pennsylvanicus*; D. E. Delzell. Studies on the chemical composition of lake bottom sediments; H. Kleerekoper. The perception of low frequency vibrations in fish; H. Kleerekoper. The perception of light in fish; H. Kleerekoper. Viruses in wild plants; W. D. MacClement. Cytology of hardiness in plants; W. D. MacClement. Ecological and genetical studies of yeasts; J. J. Miller. Fusarium wilt of muskmelon and watermelon; J. J. Miller. Experimental embryogeny; N. W. Radforth. Organic terrain organization; N. W. Radforth. Palaeobotany and developmental morphology; N. W. Radforth. Applied palaeobotany and palynology; N. W. Radforth.

Those interested should write to Dr. H. Kleerekoper, Chairman of the Department of Biology, Hamilton College, McMaster University, Hamilton, Ontario, Canada. All applications should be filed by June 1, 1953, and should be accompanied by transcript of university standings and letters of recommendation from two professors.

UNIVERSITY OF WALES

PRIFYSGOL CYMRU

A limited number of Fellowships, each of the annual value of £400 and tenable for two years, will be awarded in 1953 to graduates of the University of Wales. Candidates for the Fellowships should send their applications to the Registrar, University Registry, Cathays Park, Cardiff, not later than June 1, 1953.

Further information may be obtained from the Registrar.

UNIVERSITY COLLEGE

LONDON (GOWER STREET, W.C.1)

Leverhulme Studentships in Chemical Engineering, of value of £400 per annum, awarded for one session (renewable for second session) are awarded to graduates in chemistry or engineering to enable them to obtain advanced training or to undertake research in chemical engineering in the Ramsay Memorial Laboratory. Practical experience of factory conditions essential.

Applications, giving particulars of academic qualifications and industrial experience, with names of two referees, should be received by Registrar, not later than May 15, 1953.

ROYAL TECHNICAL COLLEGE

GLASGOW
(Affiliated to the University of Glasgow)
DEPARTMENT OF CHEMISTRY
COLVILLE FELLOWSHIP

Applications are invited from organic chemists for the Colville Fellowship, tenable in the Department of Chemistry. The value of the Fellowship is between £600 and £900 per annum, depending on the qualifications and experience of the holder. The person appointed will be required to undertake research into the chemistry of coal.

Applications, giving the names of two referees, should be sent to the Professor of Chemistry, Royal Technical College, George Street, Glasgow, by May 9, 1953.

COLLEGE OF AERONAUTICS

ENGLISH ELECTRIC RESEARCH FELLOWSHIP IN AERONAUTICS

Applications are invited for a Research Fellowship which has been established at the College by the English Electric Co., Ltd. The Fellowship is intended to provide opportunity for postgraduate research into problems of vibration or stability and control of aircraft, and is tenable for one year, beginning on or about October 1, 1953. The value of the Fellowship is £500.

Applications, giving full particulars of education and experience, and quoting the names of three referees, are required by May 1, 1953, and should be addressed to: The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

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SENIOR RESEARCH FELLOWS and RESEARCH FELLOWS TO WORK IN THE DEPARTMENT OF THEORETICAL PHYSICS, Australian National University, Canberra, on problems of nuclear and particle physics and in field theory—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

SENIOR RESEARCH WORKER and a RESEARCH ASSISTANT, to undertake a fundamental study of the viscosity of liquid metals—The Registrar, The University, Edmund Street, Birmingham 3.

TECHNICAL OFFICER (with degree or diploma in agriculture, horticulture or biology) for potato trials—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Association of Universities of the British Commonwealth. Report of the Executive Council together with the Accounts of the Association for the Year 1st August 1951 to 31st July 1952. Pp. 21. (London: Association of Universities of the British Commonwealth, 1952.) [102

University of Cambridge: School of Agriculture. Memoir No. 24: A Summary of the Papers published by the Members of the Staff of the School of Agriculture and its Associated Research Organisations during the Period October 1st, 1951—September 30th, 1952. Review Series No. 7: Field Drainage Work at Cambridge, 1930–1952. Pp. 27. (Cambridge: School of Agriculture, 1953.) 2*s*. 6*d*. [102

The Graduate in the G.E.C. Pp. v+18. (London: General Electric Co., Ltd., 1953.) [102

Registrar General's Decennial Supplement, England and Wales 1931. Part 3: Estimates of Population, Statistics of Marriage, Births and Deaths, 1921–1930. Pp. vi+574. (London: H.M. Stationery Office, 1952.) 70*s*. net. [102

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